Aalto University
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# Labor market polarization

## The routinization hypothesis and the losing middle-class

Master's Thesis
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**Abstract**

Labor market polarization refers to the observed changes in the employment structure. Since the beginning of the 1980s, there has been a notable change in the employment shares in favor of high-paid and low-paid workers at the expense of middle-paid workers. This phenomenon is detected in most industrialized Western countries and is of great importance since the middle-class represents a significant employment group in many developed countries. Thus, a decline in the middle-class may have great socioeconomic impacts. This thesis is a literature review that aims to give a deeper understanding of labor market polarization and the reasons behind it.

This thesis examines polarization over the time period 1980-2010, with a focus on the Finnish labor market. The most favored explanation for polarization is the routinization hypothesis or the so-called routine-biased technological change. This hypothesis claims that the reason behind the shrinking middle-class is the substitution of routine tasks and complementation of high-skilled workers with technology. Routine tasks tend to locate in the middle of the wage and skill distribution. Therefore, the demand for middle-class workers declines with technological improvements and the price reduction of computer capital. The routine workers affected by polarization are forced to reallocate themselves in the labor market and they frequently end up in low-paying service occupations. Thus, the recent changes in the employment structure explained by the routinization hypothesis are all in accordance with the shrinking middle-class and the changes in the employment shares in favor of low-paying and high-paying occupations we observe today.

Polarization seems to have a similar impact on the same occupations in Western countries. There is a clear winning category, namely the highest-paying occupations, whereas the middle-paying occupations come out as losers. Middle-class occupations experiencing the greatest loss in employment shares are clerks, craft and related trades workers as well as plant and machine operators and assemblers. The decline in employment shares is mainly caused by a reduced demand for industrial, manufacturing, and office workers, namely, highly routine intensive occupations. In the lowest-paying occupations, personal and protective services have gained the most employment shares, whereas managers and other professionals have been favored the most in the highest-paying occupations.

**Keywords** polarization, labor markets, routine work, routine-biased technological change

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**Tiivistelmä**

Työmarkkinapolarisaatio tarkoittaa näkyvää muutosta työllisyysrakenteessa. 1980-luvulta lähtien, korkea- ja matalapalkkaiset työt ovat kasvattaneet työllisyysosuuksiaan keskipalkkaisten kustannuksella. Polarisaatiota on havaittavissa lähes jokaisessa teollistuneessa länsimaassa. Polarisaatiolla on tärkeä merkitys, sillä keskiluokka vastaa yhtä suurinta työllisyysluokkaa monessa maassa ja sen heikentymisellä voi olla syviä sosioekonomisia vaikutuksia. Tutkielma on kirjallisuuskatsaus, jonka tarkoituksena on antaa parempi kuva polarisaatiosta ja luotettava selitys polarisaation syntymiselle.

Tutkielma tutkii polarisaatiota ajanjaksolla 1980-2010, keskittyen Suomen työmarkkinoihin. Luotettavin selitys polarisaatiolle tällä hetkellä on rutiinisuushypoteesi, joka väittää, että syy kutistuneeseen keskiluokkaan on teknologian yleistyminen ja rutiinitöiden korvaaminen teknologialla. Rutiinityö on havaittu keskittyvän palkka- ja taitojakauman keskiosaan, jonka vuoksi keskipalkkaisten kysyntä vähenee teknologian hinnan alenemisen myötä. Korkeapalkkaisten työllisyysosuuden kasvu on selitettävissä sillä, että teknologia täydentää korkeapalkkaisia ja -taitoisia työntekijöitä. Keskiluokan työntekijät joihin polarisaatio vaikuttaa, joutuvat siirtymään muihin tehtäviin ja päätyvät useimmiten matalapalkkaisiin palveluammatteihin. Nämä nykypäivän muutokset työllisyysrakenteessa selittävät kutistuvan keskiluokan ja muutokset työllisyysosuuksissa, jotka suosivat korkea- ja matalapalkkaisia keskipalkkaisten kustannuksella.

Polarisaatio on vaikuttanut melko samalla tavalla samoihin ammatteihin kaikissa länsimaissa, joissa polarisaatiota havaitaan. Polarisoiduilla työmarkkinoilla on selkeä voittaja, eli korkeapalkkaiset työntekijät, kun taas keskipalkkaiset työntekijät jäävät häviäjiksi. Keskiluokan ammatit, jotka ovat menettäneet eniten ammattiosuuksiaan ovat toimisto- ja asiakaspalvelutyöntekijät, rakennus-, korjaus-, ja valmistustyöntekijät sekä prosessi-, ja kuljetustyöntekijät. Toisin sanoen keskiluokan kutistumiseen on vaikuttanut teollisuus-, valmistus-, ja toimistotyöntekijöiden kysynnän lasku, eli paljon rutiinia sisältävät ammatit. Matalapalkkaisissa töissä eniten osuuksiaan kasvattaneet ovat palvelu- ja suojelutyöntekijät, kun taas korkeapalkkaisissa töissä vastaavat ovat johtajat ja erityisasiantuntijat, eli vähän rutiinia sisältävät ammatit.

**Avainsanat** polarisaatio, työmarkkinat, rutiinityö, rutiinisuushypoteesi

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# 1 Introduction

The Western countries have encountered for some decades now a rupture in the labor market. Technological improvements, reductions in the price of computer capital, globalization, and changes in skill requirements of occupations, have led to changes in employment opportunities of workers. At the same time, there is an increased demand for high-paid, educated workers and low-paid, service workers, but a decline in the demand for occupations that require some education and knowledge. These influence the structural changes the labor market faces today, a phenomenon called labor market polarization.

Labor market polarization refers to the observed shift in employment to high-paid and low-paid jobs at the expense of middle-paid jobs (Autor, Katz, and Kearney, 2006). Polarization in the labor market has been increasing in many industrialized countries, such as the US and Western European countries since the late 1970s and the beginning of the 1980s and seems to be still increasing. There is a vast literature on polarization and this thesis is a literature review that provides a deeper understanding of the labor market polarization.

Most industrialized Western countries have faced labor market polarization in both employment and wage structure. Polarization in the wage structure, or wage polarization, refers to the observed growth in wages of high-paid jobs and low-paid jobs, but simultaneously, a much weaker growth or even a decline in wages of middle-paid jobs. Both the changes in employment and wages encounter a similar pattern of increasing shares in the upper and lower parts of the skill distribution, and a declining share in the middle of the skill distribution. This pattern forms a so-called U-shaped trend and pictures the polarization graph where the vertical axis represents the changes in employment or wages, and the horizontal axis represents the skill distribution. The skill distribution means in this context that occupations are arranged in skill percentiles of equal size into categories by skill level, which is usually estimated by the average wage of workers (Autor and Dorn, 2013). Low-skilled or low-paid workers tend to locate at the left-hand side of the polarization graphs and high-skilled or high-paid workers at the right-hand side.

Economists usually measure the degree of labor market polarization based on the curve in the polarization graph. The more U-shaped the curve is, the more polarized is the labor market. According to recent research, Western countries have experienced different degrees of polarization

(Goos, Manning, and Salomons, 2014). In some countries, the degree of polarization is stronger, such as in the US and the UK, whereas in some countries, labor market polarization is somewhat less detectable or U-shaped. For instance, the polarization of the labor market in the Nordic countries is less obvious than in the US (Asplund, Barth, Lundborg, and Nilsen, 2011). In this thesis, I will put an emphasis on the Finnish labor market polarization.

For a more thorough measure of polarization, occupations are classified into three groups based on their skill and wage level: highest-paying occupations, middle-paying occupations and lowest-paying occupations (Goos, Manning, and Salomons, 2008; Mitrunen 2013). The degree of polarization can be measured by looking at the changes in employment shares within and between these occupational groups. Furthermore, this occupational classification reaches from the one-digit level up to the fifth-digit level (Statistics Finland, 2018b). The more digits, the more precise is the classification since more occupations are taken into account. The one-digit level includes 9 occupational classes. For instance, occupational class 1 includes *Legislators, senior officials, and managers*, class 4 *Clerks,* class 5 *Service workers, and shop and market sales workers* and so forth. Frequently, classes 1-3 belong to the highest-paying occupations, 4, 6-8 to middle-paying occupations and classes 5 and 9 to lowest-paying occupations. At the two-digit level, the nine occupational classes from the one-digit level are further divided into subclasses. The divisions into subclasses go further as the digit level increases. The benefit with this classification is that it enables cross-country and over time comparison and nearly every Western country follows this classification.

Labor market polarization is a well-researched topic and there is plenty of existing literature on polarization from the US and several Western European countries. Autor and Dorn (2013) study labor market polarization in the US over the time period 1980-2005 and find that employment growth has been particularly strong in the upper and lower parts of the wage and skill distribution, but the employment shares have declined in the middle of the distribution. Also, Cortes (2016) investigates polarization in the US over the years 1976-2007 and demonstrates that the middle-skilled workers have faced a substantial loss in employment shares in comparison to the other two occupational groups.

Goos et al. (2014) study polarization in 16 Western European countries over the time interval 1993-2010 and find evidence of a shrinking middle-class. During the observed time period, they find that the middle-paying occupations have declined 9.3 percent across all countries, whereas highest-

paying occupations have increased their shares by 5.6 percent and lowest-paying occupations by 3.7 percent. They show that those highest-paying occupations that gained most employment shares were *Corporate managers* (12), *Physical, mathematical and engineering science professionals* (21), and *Other associate professionals* (34). These occupational classes are included in the occupational classification at the two-digit level and class 12 is a subclass of class 1 at the one-digit level. In addition, the lowest-paying occupations that increased their shares the most were *Personal and protective services workers* (51), and *Sales and services elementary occupations* (91). Those middle-paying occupations affected the most were *Office clerks* (41), *Other craft and related trades workers* (74), and *Machine operators and assemblers* (82). Furthermore, they find evidence of a shrinking middle-class in all 16 countries.

Polarization is also studied in Finland. Mitrunen (2013) and Böckerman and Vainiomäki (2014) find both evidence of labor market polarization in Finland. Böckerman and Vainiomäki (2014) study job polarization in Finland during the time period 1995-2008. They find that the occupations locating in the tails of the skill distribution have increased the most, whereas the occupations in the middle of the distribution have encountered a significant decline. Mitrunen (2013) analyzes the Finnish labor market and finds similar results. Mitrunen (2013) presents that the middle-class has lost approximately 12 percentage points in employment shares in the labor market, whereas the high-skilled workers have profited nearly 7 percentage points and the low-skilled 3 percentage points in employment shares.

In accordance with Goos et al. (2014), Mitrunen (2013) shows that the occupational class 2, *Physical, mathematical and engineering science professionals (21),* belonging to the highest-paying occupations gained most shares, and class 5, *Personal and protective services workers* (51), of lowest-paying occupations. Middle-paying occupations losing employment shares were classes 4 and 7, such as occupations *Cashiers, tellers and related clerks* (421) and *Electrical and electronic equipment mechanics and fitters* (724).

There is clear evidence of a winning category in all these studies examining polarization, namely the highest-paying occupations. Furthermore, the middle-paying occupations come out as losers. What is it then that provoke polarization? Even though polarization is a broadly studied topic, there is no unanimous explanation amongst researchers. The earliest studies of polarization considered skill-biased technological change as the main explanation, which suggests that education explains the observed changes in employment shares (Katz and Murphy, 1992). This technological change

suggests that the more years of education an individual has, the more skills does this individual possess. As a result, the demand for skilled people should increase along with their wages when the labor demand and wages of non-educated workers should decline. However, we know today that this is not what has happened. The changes in employment and wages have been strongly U-shaped, so the skilled-biased technological change cannot exclusively explain labor market polarization.

Since the skill-biased technological change only explains the evolution in the top end of the wage distribution, Autor, Levy, and Murnane (2003) introduced the idea of technology replacing routine work, which was later named the routine-biased technological change by Goos et al. (2014), which is today the most favored explanation for polarization. Routine refers to methodological repetition, and the performance of routine work usually requires explicit rules and gradual procedures. Autor et al. (2003) demonstrate that computerization and the rapid advancements and adaptation of computer technology have altered the demand for human skills.

Autor et al. (2003) differentiate between routine manual, routine cognitive as well as non-routine cognitive and non-routine manual jobs. The classification is based on what tasks are needed to perform certain occupations. They claim that routine manual occupations, such as occupations requiring repetitive assembly and sorting, and routine cognitive occupations, like record keeping, calculation, and repetitive customer service, are best suited for automation. Hence, the more routine work an occupation requires, the more applicable it is for automation. A Finnish study made by Mitrunen (2013) shows that repetition is typical for middle-paying occupations. He observes that routine intensity of occupations increases in the middle of the skill distribution and decreases at the fringes. Thereby, one common divisor of the shrinking middle-class is the high intensity of routineness.

Autor et al. (2003) continue with arguing that computerization and the continuously decreasing price of technology increase the demand for education. This results in an increase in the demand for highest-paying occupations that require non-routine cognitive tasks, such as legal writing, medical diagnosis, and persuasion. Moreover, Autor and Dorn (2013) show in their study that most of the middle-class workers in routine tasks, substituted by computer capital, reallocate their labor supply to the bottom end of the wage distribution. These workers tend to end up in low-skilled service occupations, consisting of personal and protective services. Service occupations are proven hard and expensive to automate since they require non-routine manual tasks, such as finger dexterity and direct physical closeness.

The recent changes in the employment structure explained by the routinization hypothesis are all in accordance with the shrinking middle-class and the U-shaped changes in the employment shares we observe today. The changes in the employment shares are in most cases biased in favor of highest-paying occupations, whereas the middle-class ends up as a loser.

The structure of this thesis is the following: the second section presents the theory of the labor market polarization. In addition, I present the changes in the employment shares in the US and 16 Western European countries based on existing literature. The third section explains the most probable explanation for polarization, namely the routine-biased technological change. I also go through briefly some other alternative explanations for labor market polarization since some research papers have begun to question this explanation. The fourth section presents polarization in the Finnish labor market and lays out the main findings of polarization in Finland. In addition, I compare the labor market outcomes in the Nordics during the time interval of 1996 and 2006. The fifth section tries to identify the effects of polarization and the routinization hypothesis on individual workers and the losers and winners in the labor market. The sixth section concludes.

# 2 Labor market polarization

Labor market polarization refers to the observed shift in employment to high-paid and low-paid jobs at the expense of middle-paid jobs (Autor et al., 2006). Another characteristic feature for the development of polarization is that the employment shares of occupations located at the fringes of the skill distribution increase when the employment shares of occupations situated in the middle decrease (Acemoglu and Autor, 2011). Polarization is detectable in nearly all industrialized Western countries. However, the degree of labor market polarization highly differs between these countries. To facilitate the measurement of polarization, occupations are generally classified into groups based on their skill level or by skill requirements to perform a certain task.

Polarization has been increasing in Western developed countries ever since the late 1970s or the beginning of the 1980s. The first research on polarization was made in the US (Acemoglu, 1999), and the interest for this topic originates from the increased wage inequality of high-skilled and low-skilled people detected in the 1980s (Katz and Autor, 1999; Card and DiNardo, 2002).

Polarization is not a new phenomenon. Katz and Margo (2014) have studied the changes in labor demand and the impact of technological advancements on labor in the US from a historical perspective. According to their findings, polarization has been present also during the 1900th century. At that time, technological improvements made many middle-paid artisans and craftsmen redundant due to mass production.

## 2.1 Measurement of polarization by occupational classification

An occupation refers to a job an individual performs, and different occupations usually require different sets of skills. To improve the comparability of employment structures and wages between different times and different locations, occupations are classified into groups in accordance with their job task requirements. These requirements refer to skills that are necessary to perform a certain job. (Statistics Finland, 2018b). Based on these skill levels, we separate between three

groups: highest-paying occupations, middle-paying occupations and lowest-paying occupations (Goos et al., 2008; Mitrunen, 2013).

The occupational classifications reach from the one-digit level up to the five-digit level. The higher the digit level, the more precise is the classification since more occupations are taken into consideration. The most moderate classification is at the one-digit level, which contains generally nine different occupational classes. At the two-digit level, the nine occupational classes from the one-digit level are further divided into subclasses. The divisions into subclasses go further as the digit level increases. To separate between the levels, the levels are marked with a numerical code. For instance, the one-digit level has a one-digit code number (1-9) and the two-digit level has a two-digit code, from 11 onwards. (Statistics Finland, 2018b)

The ISCO-88 (International Standard Classification of Occupations) by the International Labour Organization (ILO) and the United Nations (UN) is based on international standards. ISCO-88 goes from the one-digit level down to the five-digit level. The one-digit level includes 9 occupational classes, whereas the two-digit occupational level consists of 43 occupational classes and the three-digit level consists of 130 occupational classes. The benefit with this classification is that it enables cross-country and over time comparison, and nearly every Western country follows this classification. (Statistics Finland, 2018b)

However, cross-country comparison of labor market polarization must be made with caution, because there might be some country-specific differences (Asplund et al., 2011). For instance, in one country an occupation may classify as a middle-paying occupation, whereas in another country the occupation might belong to the lowest-paying occupations. These cross-country differences must be considered when comparing polarization rates of different countries.

Finland has also an own classification system, Classification of Occupations 2010, which goes down to the four-digit level. There is also a common classification system for the EU Member States, ISCO-88(COM). However, the structures of these occupational classifications are similar, apart from some minor differences between the classification of some occupations. The one-digit level of the ISCO-88 is presented in table 1 and includes nine occupational classes.

*ISCO-88 occupational classification*

1. *Legislators, senior officials, and managers*
2. *Professionals*
3. *Technicians and associate professionals*
4. *Clerks*
5. *Service workers and shop and market sales workers*
6. *Skilled agricultural and fishery workers*
7. *Craft and related trades workers*
8. *Plant and machine operators and assemblers*
9. *Elementary occupations*

*Table 1: The international occupational classification at the one-digit level. Source: ILO (2004).*

The occupational classifications take into account job task requirements or set of skills of employees. In labor economics, skill has two meanings - skill level and skill specialization. Skill level refers to the scope and complexity of tasks whereas skill specialization refers to the knowledge, tools, and machinery required to perform a task. In polarization theory, we mostly use skill level. (Statistics Finland, 2018b) For example, in table 1, according to the international classification system ISCO-88, occupations in classes 4-8 require the same skill level, while classes 1-3 require a higher skill level and class 9 a lower skill level. (Statistics Finland, 2018b). To separate between these classes even further, the classification considers the average wages of every occupation. As a result, the occupations are divided into groups as follows: classes 1-3 belong to the highest-paying occupations, 4, 6-8 to middle-paying occupations and classes 5 and 9 to lowest-paying occupations.

This division and the occupational classification enable measuring polarization by looking at the changes in employment shares and wages within and between these occupational groups. According to Mitrunen (2013), the employment shares of classes four and six have decreased the most, and service occupations in class five have increased their employment share the most. For instance, *Other personal services workers* (514) and *Protective services workers* (516), which are found at the three-digit level as subclasses of class 5, have gained substantial employment shares. In comparison, *Secretaries* (4115), as well as *Library and filing clerks* (4141) have faced a significant decrease in employment shares. These occupations belong to the four-digit level, which are

subclasses of class four. The numbers in parentheses refer to the occupational codes of each occupational class. [1]

## 2.2 Job polarization

Labor market polarization is a well-researched topic and there is plenty of existing literature on polarization from the US and several Western European countries. To mention but a few, Autor, Katz, and Kearney (2006); Acemoglu and Autor (2011); Autor and Dorn (2013); and Cortes (2016) have researched polarization in the US. Moreover, Goos and Manning (2007); Oesch and Rodriguez Menés (2010); and Goos, Manning, and Salomons (2014) have studied polarization in Western European countries. Polarization has also been a hot topic in the Nordics, Mitrunen (2013); Böckerman and Vainiomäki (2014); and Kauhanen and Maczulskij (2016) study polarization in Finland while Asplund, Barth, Lundborg, and Nilsen (2011) examine the Nordic labor market polarization. All of these studies find at least some hints of polarized labor markets.

One common measure of polarization is the so-called U-shaped curve picturing changes in employment shares. In most Western countries, employment has encountered a U-shaped curve along the skill or wage distribution in the so-called polarization graph. In this graph, the skill or wage distribution is on the horizontal axis and changes in employment shares on the vertical axis. The U-shaped curve implements that the employment shares of high-skilled and low-skilled workers have increased substantially in comparison to workers located in the middle of the skill or wage distribution. The skill distribution ranks workers into skill percentiles based on required education or skill level, which, on the other hand, is frequently estimated by the mean wage (Autor and Dorn, 2013). Although we cannot claim that the wage level is a perfect substitute for skill level, there is a somewhat clear correlation between those two. Thereby, the wage level is a relatively good indicator for skill level. (Mitrunen, 2013)

[1] See https://www.ilo.org/public/english/bureau/stat/isco/isco88/major.htm for more information on the ISCO-88 classification system.

The skill percentiles are commonly divided into quintiles, and the first quintile, or the 20th skill percentile, refers to the point at which one-fifth of the occupations lie below. For instance, high-school graduates and low-paid workers situate normally at the bottom end of the skill distribution and by contrast, college graduates and high-paid workers situate at the top end of the skill distribution. The wage distribution, on the other hand, ranks wages into deciles, where number one represents the bottom ten percent earners and number ten represent the top ten percent earners.

Autor and Dorn (2013) study labor market polarization in the US over the years 1980-2005 and its effect on the employment and wage structure. To calculate changes in employment shares between the years 1980 and 2005, the authors use data from Census Integrated Public Use Micro Samples from the years 1950, 1970, 1980, 1990 and 2000, and the American Community Survey in 2005. Both data sources give information on industries, education, earnings and occupation variables of workers aged 16-64, who were working in the year prior to the survey. The American Community Survey complements the Census data for the year 2005. The authors focus on the years 1980-2005 because the classification system used, changed during the years 1970 and 1980. This change complicates the overtime comparison before the 1980s. (Autor and Dorn, 2013)

To measure the changes in employment shares, Autor and Dorn (2013) have determined the employment share of an occupation as the share of total work hours. Autor and Dorn (2013) include in their study 318 occupations at the three-digit level, consisting of all US nonfarm payroll employment.[2] The occupations are further organized by skill level based on the average log wage of employees in all occupations in the year 1980. Autor and Dorn (2013) find that employment growth has been particularly strong in the upper skill quintile and correspondingly, employment growth has also been present in the lowest skill quintile. Autor and Dorn (2013) claim that the increase in the lower part of the distribution stems from the rise of one specific occupational class, namely service occupations. These service occupations include workers offering personal and protective services such as travel attendants, cooks, waiters, housekeepers, child-care workers, hairdressers, beauticians, police officers, fire-fighters, etc.

However, in the second and third quintile, that is, in the middle-paying occupations, employment shares have declined. Autor and Dorn (2013) argue that based on these results, polarization has been exceptionally strong during the observed period. Figure 1 presents the U-shaped curve of

[2] Nonfarm payroll employment includes all manufacturing, constructing and goods-producing companies.

changes in the employment structure in the US labor market. The skill distribution is on the horizontal axis and percentage changes in employment shares on the vertical axis.


*Figure 1: Changes in employment by skill percentile in the US labor market over 1980-2005. Source: Autor and Dorn (2013).*

The value 0.1 on the vertical axis refers to a 10 percent increase in employment while -0.1 refers to a 10 percent decline in employment. In addition, the greater the skill percentile is on the horizontal axis, the more skilled is a person or the more education does an occupation require. We observe that the highest-paying occupations have increased by approximately 10-30 percent, lowest-paying occupations by 0-25 percent, but that middle-paying occupations have declined at most by 10 percent.

Furthermore, Cortes (2016) investigates polarization in the US over three decades over the years 1976-2007. He uses the Panel Study of Income Dynamics data, which allows studying individual workers at the three digit-level from various cohorts by their social behavior, earnings and economic health.[3] To measure polarization over time, Cortes (2016) divides occupations into three groups based on their skill level following Acemoglu and Autor (2011). The first group includes the least

[3] The sample only includes males that take the role of household heads, are aged between 16 to 64 and work in nonagricultural and nonmilitary occupations.

skilled workers, the second refers to the middle-skilled workers and the third group includes the highest-skilled workers.

When presenting the changes in the employment shares in the long-run, Cortes (2016) finds that during 1976-2007, middle-skilled workers have faced a substantial loss in employment shares, whereas the low-skilled and high-skilled compensated the decrease by increasing their shares. In the short-run, there are significant variations across the investigated three decades. During the first decade, 1976-1987, the occupational group that has been favored the most is the high-skilled workers. The middle-skilled workers have declined the most during this time period, while the low-skilled workers faced a modest increase in comparison to the high-skilled workers. (Cortes, 2016)

In 1987-1997 there were no substantial changes in the employment shares according to the study of Cortes (2016). He finds that for the low-skilled and middle-skilled workers, the changes in employment shares were barely positive, while the trend for high-skilled workers surprisingly turned slightly negative. Over 1997-2007 the same negative trend for high-skilled workers continued and the middle-skilled workers faced a sharp decline in employment shares yet again. Hence, all of the growth in employment shares happened at the bottom end of the skill distribution during this decade. Thus, as Cortes (2016) shows, labor market polarization has been continuing at least ever since the 1980s.

This outcome is in line with the study of Autor and Dorn (2013). They showed in their study that between 1980 and 2005, the employment shares of low-educated workers, particularly, in service occupations, increased by approximately 30 percent. Also, Beaudry, Green, and Sand (2016) demonstrate in their study that during the 2000s, the demand for high-skilled workers has declined. The authors state that the high-educated workers have moved down the wage distribution, while middle-skilled workers have shifted down to lowest-paying occupations. Beaudry et al. (2016) call this phenomenon ‘de-skilling’, which implies that more and more high-educated workers become middle-class workers.

In addition, Goos et al. (2014) study polarization in 16 Western European countries over the time interval 1993-2010. The authors use the European Union Labour Force Survey to estimate the degree of polarization across countries. The data shares information on individuals aged 15 and over on employment status, labor market participation, and hours worked per week at the two-digit level. The data enables cross-country comparison since the data is harmonized by using an

international classification system[4] and by following the same guidelines and concepts in every country. The data includes all 28 EU-member states, but due to some limitations, such as missing data from new member countries, the authors exclude 12 countries from their study. The countries investigated are the following: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, and the UK. (Goos et al., 2014)

To measure changes in employment shares over time, Goos et al. (2014) exploit weekly work hours from the Labour Force Survey and earnings information from the European Community Household Panel and the European Union Statistics on Income and Living Conditions. They rank 21 occupations according to their average wages across all countries and years into three groups: 4 lowest-paying occupations, 9 middle-paying occupations, and 8 highest-paying occupations. Then, Goos et al. (2014) calculate the percentage changes in employment shares in these groups across the 16 countries.

Goos et al. (2014) find evidence of a shrinking middle-class. When pooling employment for all occupations together over all countries, they find that the middle-paying occupations have declined 9.3 percent during the observed time period. The highest-paying and lowest-paying occupations have on the contrary increased their employment shares by 5.6 percent and 3.7 percent respectively. They observe that those highest-paying occupations that gained most employment shares are *Corporate managers* (12), *Physical, mathematical and engineering science professionals* (21), *Other professionals* (24), and *Other associate professionals* (34).[5] Moreover, the lowest-paying occupations that increased their shares the most were *Personal and protective services workers* (51), and *Sales and services elementary occupations* (91). The employment shares of middle-paying occupations are decreasing in almost all occupational classes. Those affected the most are *Office clerks* (41), *Metal, machinery and related trades workers* (72), *Other craft and related trades workers* (74), and *Machine operators and assemblers* (82).

When examining polarization at the country level, the results are consistent with the results when employment was pooled across countries. Goos et al. (2014) show that in every country, the share of middle-paying occupations has declined, and the share of highest-paying occupations has

[4] Goos et al. (2014) use the ISCO-88 classification system at the two-digit occupational level in their research.
[5] These are all subclasses at the two-digit level of groups 1-3 at the one-digit level. The numbers in parentheses refer to the occupational codes of each occupational class.

increased. Lowest-paying occupations were also increasing in all countries but two, namely Finland and Luxembourg.

Their results are visible in figure 2, where the vertical axis shows the percentage changes in employment shares of the three occupational groups. We observe that the lowest-paying occupations have gained growth in all countries but Finland and Luxembourg, which either faced a very week polarization or did not face labor market polarization at all. We can also demonstrate with the help of figure 2 that the degree of polarization has been particularly strong in Austria, Italy, Greece and in the UK.

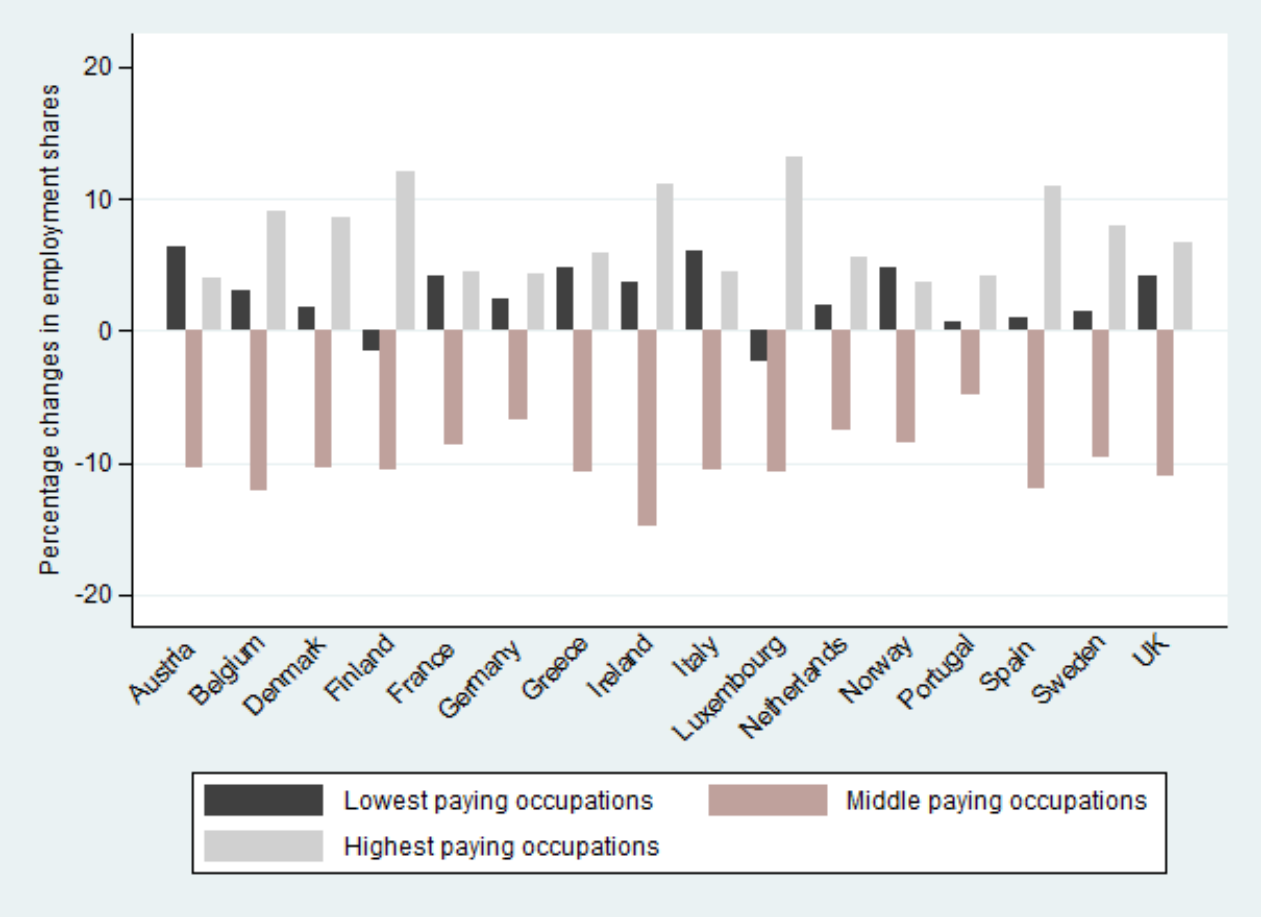


*Figure 2: Percentage point changes in employment shares in occupational groups in 16 western countries over the time period 1993-2010. Data from Goos et al. (2014).*

## 2.3 Wage polarization

We can see that the changes in the employment structure are biased in favor of especially high-paid workers but also low-paid workers and against middle-paid workers. In addition, there has been significant growth in wages of especially high-paying jobs but also of low-paying jobs since the beginning of the 1980s (Katz and Autor, 1999; Acemoglu and Autor,2011).

Recent research on labor market polarization has begun to separate between job and wage polarization. Job polarization refers to the observed shifts in employment to the fringes of the wage or skill distribution, whereas wage polarization refers to the changes in the wage structure. These changes imply an observed growth in wages of high-paid jobs and low-paid jobs but simultaneously, a much weaker growth or even a decline in wages of middle-paid jobs. Autor and Dorn (2013) explain that wage polarization occurs when the relative wage of low-paid workers increases in relation to the corresponding wage of middle-paid workers. In addition, the wage ratio between high-paid workers and low-paid workers should simultaneously decline or remain stable. Otherwise, the wages of low-skilled workers would become steadily smaller than those of high-skilled workers. (Autor and Dorn, 2013).

Autor and Dorn (2013) examine wage polarization in the US over the time period 1980-2005. To estimate the changes in the wage structure and real hourly wages, the authors use the same data and methods as presented in the previous section, that is, the Census IPUMS and American Community Survey. They calculate the average log wage of employees in all 318 occupations in the year 1980. The real hourly wage is calculated by the yearly wage times earnings income, divided by the number of weeks worked times weekly hours (Autor and Dorn, 2013).

Figure 3 presents the findings of Autor and Dorn (2013) on changes in real hourly wages. As in figure 1, we observe that the wage growth faces the same U-shaped curve along the skill distribution. The value 0.15 means that the real hourly wages have grown 15 percent. Autor and Dorn (2013) find that wage growth has favored the top end of the distribution the most, whereas the bottom end has faced a modest increase. However, the middle-class has benefited considerably less with respect to the others.


*Figure 3: Changes in real hourly wages by skill percentile in the US labor market over 1980-2005. Source: Autor and Dorn (2013).*

Cortes (2016) also finds that the increase in the wage level for high-paying and low-paying jobs compensates for the decrease in the wage level for middle-paying jobs. The wage level depends on two factors: the task the worker performs and the individual skill level. Thereby, the wage of a worker is composed of two premia. The first is an "occupation-specific premium", which is the same for all workers in a specific occupation. The second component of the potential wage is an "occupation-specific return to the worker's skill". The latter may differ across workers performing the same task in an occupation. (Cortes, 2016) Gibbons, Katz, Lemieux, and Parent (2005) claim that the skill premium varies heavily across occupations and becomes higher when shifting upwards along the skill distribution. For instance, Cortes (2016) argues that the wage premium for middle-paying jobs has declined nearly 17 percent from the mid-1970s to 2000. During the same period, the wage premium for highest-paying occupations has increased by approximately 25 percent relative to the premium of lowest-paying occupations.

The two different phenomena of polarization have different impacts on the wage dispersion at different points on the wage distribution. On one hand, wage polarization decreases the wage dispersion at the bottom end of the wage distribution because the wage growth is relatively stronger in low-paid occupations than in middle-paid occupations. On the contrary, job polarization

increases the wage dispersion at the bottom end of the distribution since the employment share of low-paid workers increases significantly more in relation to middle-paid workers. (Böckerman and Vainiomäki, 2014)

On the other hand, both wage and job polarization increase the wage dispersion at the top end of the wage distribution (Böckerman and Vainiomäki, 2014). The first because wage growth is higher in highest-paying occupations than in middle-paying occupations, and the latter because the demand of high-paid workers is greater than the demand of middle-paid workers. Depending on the degree of both wage and job polarization, labor market polarization can either increase the wage dispersion between occupations, thus increase wage inequality of an economy, or have a decreasing effect on the wage dispersion.

There are many suggested explanations for polarization, and economists studying this topic have proposed several factors and alternative explanations causing polarization. It is important to emphasize that there is no unanimous explanation for polarization amongst researchers. However, there is one common feature for the shrinking occupations; namely the routine intensity of those occupations (Mitrunen, 2013).

# 3 Potential explanations behind polarization

## 3.1 Skill-biased technological change

The earliest studies on polarization consider the skill-biased technological change[6] as the leading explanation for labor market polarization (Katz and Murphy, 1992; Juhn, Murphy, and Pierce, 1993; Berman, Bound, and Machin, 1998). This technological change suggests that education explains the observed changes in employment shares. In economics, years of education or the educational degree, measure whether a person is high-skilled or low-skilled. For instance, a person with a high-school degree counts as a low-skilled worker, whereas a college graduate counts as a high-skilled worker.

The basic idea of the skill-biased technological change stems from the so-called canonical model (Acemoglu and Autor, 2011). The canonical model implies that there are at least two types of skilled workers, high-skilled and low-skilled. These two different workers perform tasks and produce outputs that are imperfectly substitutable. The canonical model further proposes that technology is considered having a complementing impact on either skill group. (Katz and Murphy, 1992) According to Borjas (2016), computer capital commonly has a complementing effect on high-skilled workers and a substituting effect on low-skilled workers.

The skill-biased technological change suggests that the higher the required skill level of an occupation, the more do technological advancements favor the occupation and increase its demand (Tinbergen, 1974). In addition, the falling price of computer capital and technological improvements drive the increased demand even more. As a result, the employment shares of high-educated workers increase in contrast to the employment shares of low-educated workers.

The use of computers at work has improved remarkably the marginal productivity of educated workers in high-paid jobs. In addition, we know that assembly line workers in manufacturing jobs are easily replaced by machines and become thereby redundant. Both evolutions are explained by the SBTC. However, the changes in employment shares are challenging to explain with education or

[6] Hereafter SBTC.

the canonical model, since the employment shares of middle-skilled workers have declined when the employment shares of low-skilled workers have increased (Mitrunen, 2013). Middle-skilled workers lie in the middle of the skill distribution, which means that middling jobs require at least some education. According to the skill-biased technological change, the curve in the polarization graph should rather be upward sloping than U-shaped.

In spite that the SBTC has succeeded in explaining changes in employment shares for several years, this technological change cannot exclusively explain recent evolvements caused by labor market polarization (Autor and Dorn, 2013; Goos et al. 2014). The changes in employment shares have been strongly U-shaped, and this technological change explains only the peak in employment and wages in the upper tail of the wage distribution but not the peak in the lower tail.

## 3.2 Routine-biased technological change

Since recent research questions the validity of the SBTC, a new explanation for polarization has been introduced. Autor, Levy, and Murnane (2003) were the first to consider the routinization hypothesis. They introduced the idea of technology replacing not low-skilled tasks, but routine work. Routine refers to methodological repetition, and the performance of routine work usually requires systematic rules and procedures. It is important to emphasize that by routine work, economists do not mean easy or mundane work, but that a task can be decomposed into smaller parts and executed by a machine or computer (Acemoglu and Autor, 2011).[7] Hence, the more routine intensive a job is, the more applicable it is for substitution with computer capital. Furthermore, Mitrunen (2013) shows that repetition is typical for middling jobs and that routine intensity of occupations increases in the middle of the skill distribution and decreases at the ends of the distribution.

Goos et al. (2014) later renamed the routinization hypothesis the routine-biased technological change[8], which is currently the leading explanation for polarization (Bárány and Siegel, 2018;

[7] For instance, assembly line work is easier to decompose into smaller parts and be performed by a machine, whereas low-skilled tasks such as cleaning and haircutting are not.
[8] Hereafter RBTC.

Mitrunen, 2013; and Autor et al., 2003). Goos et al. (2014) claim that this technological change explains better today's labor market polarization than its predecessor, the skill-biased technological change. The main idea behind the routinization hypothesis is that, on the one hand, the continuously falling price of computer capital and the rapid advancements in technology, lead to an increase in demand for high-skilled workers. On the other hand, they lead to a decline in the demand for routine jobs, which are easily replaced by computers. Autor et al. (2003) separate occupations into non-routine cognitive, routine, and non-routine manual jobs. Non-routine cognitive jobs refer to high-skilled jobs, routine jobs refer to middle-skilled jobs and non-routine jobs to low-skilled jobs. This increased demand for educated workers stems from the increased marginal productivity of especially non-routine cognitive workers induced by computers (Autor et al., 2003).

Along with the decreasing price of technology, the substitution and complementarity of computers increase the relative demand for educated workers with a comparative advantage in non-routine jobs (Autor et al., 2003). Thus, the increased demand for high-skilled labor and the decline in routine jobs, or as Mitrunen (2013) demonstrates, middle-skilled jobs, are in accordance with the U-shaped curve the labor market faces today. Autor et al. (2003) demonstrate with their production model that the demand for routine jobs has shifted towards a demand for non-routine cognitive jobs due to computer capital. In their model, Autor et al. (2003) make three assumptions. Firstly, computer capital substitutes more easily routine tasks than non-routine tasks. Secondly, routine and non-routine tasks are imperfect substitutes. Thirdly, the greater the routine intensity of an occupation, the greater the marginal productivity of non-routine tasks. In this model, non-routine and routine tasks are q-complements. This implies that when one increases, the other increases, which is consistent with the second assumption.

Based on these assumptions, the authors use a general equilibrium production model, which takes the form of a Cobb-Douglas production function,[9]

$$(1) \qquad Q = (L_R + C)^{1-\beta} L_N^{\beta}, \beta \in (0,1),$$

[9] This model takes into consideration only high-skilled, non-routine cognitive tasks, thereby, leaving out low-skilled, non-routine manual tasks. Next section goes through the differences in occupational tasks and their composition in more detail.

where Q represents output, which is produced by two task inputs, routine and non-routine, and takes the price of one. $L_N$ and $L_R$ stand for non-routine and routine labor inputs, C is computer capital. These three inputs are all measured in efficiency units of labor. The supply of computer capital is perfectly elastic, taking the market price ρ. ρ is an exogenous factor that declines over time with technological improvements and represents the causal force in this production model. (Autor et al., 2003)

The authors continue the model by assuming a great number of workers maximizing their incomes. All these workers have an inelastic supply of one labor unit and different skill levels in routine and non-routine tasks, thus $E_i = [r_i, n_i]$ and $1 \geq r_i, n_i > 0 \; \forall \; i$. This implies that a worker chooses to supply $r_i$ efficiency units of labor input in routine tasks, $n_i$ efficiency units of labor input in non-routine tasks, or any other linear combination of these two inputs. Thus, $L_i = [\lambda_i r_i, (1 - \lambda_i) n_i]$, where $0 \leq \lambda_i \leq 1$. The model suggests that workers choose their inputs according to their comparative advantage. (Autor et al., 2003)

Hence, there are two main conditions that determine the market equilibrium in this model. The first condition concerns the first assumption of computer capital being a better substitute for routine work. This implies that the wage of routine workers declines when the price of computer capital goes down, thus

$$w_R = \rho. \tag{2}$$

The second condition assumes that the self-selection of workers among routine and non-routine tasks clears up the labor market.

The relative efficiency $\eta_i$ of worker $i$ in non-routine tasks to routine tasks is determined as $\eta_i = n_i / r_1$, where $\eta_i \in (0, \infty)$. The marginal worker supplies either labor to routine tasks if $(\lambda_i = 1) \; if \; \eta_i < \eta^*$, or in other case to non-routine tasks $(\lambda_i = 0)$. In equilibrium, a worker is assumed to be indifferent between working with routine and non-routine tasks according to

$$\eta^* = w_R / w_N. \tag{3}$$

To generate the supply of labor, Autor et al. (2003) estimate the functions for workers' total skill levels in routine tasks, $g(\eta)$ and in non-routine tasks, $h(\eta)$, when η takes which ever value. Thus, $g(\eta) = \sum_i r_i \cdot I[\eta_i < \eta]$ and $h(\eta) = \sum_i n_i \cdot I[\eta_i \geq \eta]$. I[·] indicates the indicator function. The

authors assume in their model that $g(\eta)$ is continuously downward sloping regarding η and $h(\eta)$ is continuously upward sloping regarding η.

Furthermore, Autor et al. (2003) expect that the labor market evolves according to the demand curve. Thus, the productive efficiency demands that

$$(4) \qquad w_R = \frac{\partial Q}{\partial L_R} = (1-\beta)\theta^{-\beta} \quad and \quad w_N = \frac{\partial Q}{\partial L_N} = \beta\theta^{1-\beta},$$

where θ refers to the ratio between the production task input of routine to non-routine:

$$(5) \qquad \theta \equiv \big(C + g(\eta^*)\big)/h(\eta^*).$$

Equations (4) and (5) generate the conditions for equilibrium for the endogenous variables in this model, namely $w_N, w_R, \theta, C, \eta$. These variables help to identify the effect of the price reduction of computer capital on labor input and wages in routine and non-routine tasks, and on the labor supply. A decline in ρ leads to workers replacement of tasks due to the fact that the reaction of the relative supply of tasks is elastic to the relative wage level. Equation (2) demonstrates that a reduction in the price of computer capital leads to a reduction in wages of routine tasks $w_R$ as following: $\partial(ln\ w_R)/\partial(ln\ \rho) = 1$. Thereby, the demand for task inputs in routine jobs increases:

$$(6) \qquad \frac{\partial\ ln\ \theta}{\partial\ ln\ \rho} = -\frac{1}{\beta}.$$

From the firms' perspective, the decline in $w_R$ and increase in demand for $L_R$ is met either by increasing the share of computer capital or routine labor input. Additionally, due to the second assumption of non-routine and routine tasks being imperfect substitutes, thus q-complements, $w_N$ increases when ρ decreases:

$$(7) \qquad \frac{\partial\ ln\ (w_N/w_R)}{\partial\ ln\ \rho} = -\frac{1}{\beta} \quad \text{and} \quad \frac{\partial\ ln\ \eta^*}{\partial\ ln\ \rho} = \frac{1}{\beta}.$$

As a result, workers will alter their supply of labor input in favor of non-routine tasks at the expense of routine tasks. Thereby, the firms respond to the increased demand for $L_R$ by an increase in computer capital.

The model by Autor et al. (2003) shows that an exogenous reduction in the cost of computer capital increases the demand and marginal productivity of non-routine labor, whereas it decreases the

demand for routine labor. This implies that routine workers redistribute their labor supply to non-routine tasks. Autor and Dorn (2013) explain further that highly routine intensive labor markets adopt technology differently than areas with low routine intensity. Accordingly, these routine intensive areas should experience a stronger degree of polarization.

Furthermore, Autor and Dorn (2013) prove in their research paper that most of the middle-class workers in routine tasks, substituted by computer capital, reallocate their labor supply to the bottom end of the wage distribution. These workers tend to end up in low-skilled service occupations, consisting of personal and protective services. Service occupations are proven hard and expensive to automate since they require non-routine skills such as finger dexterity and direct physical closeness (Autor and Dorn, 2013). Therefore, the RBTC explain well the shrinking middle-class and the polarization of the labor markets by reallocation of work and increased labor demand for high-skilled workers.

The RBTC and labor economics explain also the changes in the relative wages along the wage distribution. As acknowledged, the demand for educated workers has increased due to both the increased computer-related productivity of high-skilled workers and the price decline of technology. When the market faces a positive demand shock, the demand curve shifts up (Borjas, 2016). This shift increases the employment and wages of employees (Borjas, 2016). Hence, regarding high-skilled workers, the increased productivity and reduction in the price of computer capital result in a wage increase in the upper parts of the wage distribution.

The RBTC explains the detectable changes in the wage structure in the lower parts of the wage distribution as well. Manning (2004) argues that the wages of low-paid workers increase since once the wages of high-paid workers increase, their demand for personal services produced by low-skilled workers face inflation. This increased demand results in an increase in personal service occupations, which, on the other hand, results in an increase in the wages of the workers in these occupations (Cortes, 2016).

Autor et al. (2003) remark that there have been measurable changes in occupations and their task compositions. To measure, which occupations are applicable for automation, the authors divide them into four groups based on what types of task requirements they require. The following section describes the content of different occupational tasks.

### 3.2.1 Task content of occupations

Different occupations require different skill sets. Economists, studying labor market polarization, divide occupations into groups according to their task requirements. For instance, high-paying occupations like corporate managers and engineering professionals require skills like problem-solving, complex communication and analytical skills. These skills form the task content of an occupation.

Autor et al. (2003) study the impact of technology and computerization on skill demand. They investigate how the improvements in technology change the composition of tasks in different occupations, and how this alters the demand for human skills. Autor et al. (2003) attempt to examine, which occupations are the most substitutable with computer capital by differentiating between routine manual, routine cognitive as well as non-routine cognitive and non-routine manual jobs. The classification is based on tasks that are required to perform certain occupations. Numerous research papers studying polarization and published after Autor et al. (2003) utilize the same classification (Acemoglu and Autor, 2011).

Autor et al. (2006) exploit this classification developed by Autor et al. (2003). They rename the categories and divide them into only three groups: manual, routine and abstract jobs. Abstract jobs consist usually of the same features as non-routine cognitive jobs, whereas manual jobs consist of the same features as non-routine manual jobs. Routine jobs, or middle-class jobs, on the other hand, consist of routine manual and routine cognitive jobs. Typically, these different occupations require a diverse set of tasks. Abstract or non-routine cognitive jobs are in general performed by high-skilled workers and located in the upper parts of the skills distribution. Abstract jobs require complex tasks, such as problem-solving, judgment and complex verbal skills, which are proven difficult to computerize (Deming, 2017). The ISCO-88 classify *Legislators, senior officials and managers* (1) and *Professionals* (2) into abstract occupations at the one-digit occupational level.

Manual or non-routine manual jobs are correspondingly hard to automate because they require human interaction and flexibility. As abstract jobs locate in the upper parts of the skills distribution, manual tasks belong to the lower parts of the distribution. Hence, manual jobs often employ low-skilled workers. According to the ISCO-88 classification, one example of manual jobs is *Service*

*workers and shop and market sales workers* (5). Routine manual and routine cognitive occupations, on the other hand, are regarded as easily automated middle-class jobs since they require strict rules, systematic processes and finger dexterity (Goos and Manning, 2007). Computer capital can conveniently replace corresponding tasks. The ISCO-88 lists the following as ordinary routine occupations: *Clerks* (4), *Craft and related trades workers* (7), and *Plant and machine operators and assemblers* (8). Table 2 demonstrates the different task requirements of these four occupational categories and provides some insights on which occupation belongs to which category.

| | Routine | Non-routine |
|---|---|---|
| Manual | Finger dexterity and precision<br><br>e.g. Craft, metal and machinery workers | Human interaction, coordination and flexibility<br><br>e.g. Personal and protective services |
| Cognitive | Standards, strict rules and tolerance<br><br>e.g. Office clerks and other customer service clerks | Problem solving and complex verbal communication<br><br>e.g. Corporate managers and medical doctors |

*Table 2: Task requirements of different occupational categories.*

### 3.2.2 Routine intensity of occupations

To emphasize further the reliability of the routine-biased technological change as the leading explanation for labor market polarization, I demonstrate with the study of Mitrunen (2013) that routineness is a characteristic feature of middle-class jobs. In addition, he shows that routine jobs

usually locate in the middle of the wage and skill distribution. This supports the idea of a shrinking middle-class due to improvements in technology.

In general, middle-class jobs require some knowledge and education and locate therefore in the middle of the skill distribution. However, an even more characteristic feature of middling jobs is the routineness of work; they require repetition, monitoring, and follow strict and systematic procedures (Autor and Dorn, 2013). These features make routine jobs easily substitutable since we can decompose them into smaller parts, which then can be performed by computers even more efficiently. Autor et al. (2003) claim that occupations need to consist of tasks that are not decomposable to survive.

Measuring the routine intensity of different occupations is complicated. Autor et al. (2003) use data from the US Department of Labor's Dictionary of Occupational Titles (DOT) to study the routineness of occupations. This data collects information from the US on job task requirements for several occupations at the three-digit occupational level. In comparison to the ISCO-88 classification where there are 130 occupations, this three-digit level contains approximately 140 industries. In their study, they measure the routine intensity and changes in job task requirements. The authors mention some limitations in their data, which may affect the robustness of their results. For instance, the sampling of occupations is limited, especially, in service occupations. Furthermore, some significant set of skills are omitted, such as interpersonal and physical requirements connected to service occupations. (Autor et al., 2003) Also, the usefulness of DOT diminished when the economy moved towards an industry that emphasizes information and services rather than heavy industries.

To measure routine intensity, the authors identify different task requirements. They find that task requirements for non-routine cognitive occupations include control, planning and quantitative reasoning, and for non-routine manual tasks "eye-hand-foot coordination". Correspondingly, routine cognitive occupations require set limits, tolerance, and standards, whereas routine manual occupations demand finger dexterity.[10] Based on the DOT data, the authors calculate the percentage share of routine occupations in an industry. The amount of 'routine cognitive' and

[10] Routine cognitive jobs include i.e. Office clerks (41) and Customer service clerks (42), whereas routine manual jobs include Machine operators and assemblers (82) at the two-digit level.

'routine manual' occupations consist of, measures the share of routine in an industry. (Autor et al., 2003)

Acemoglu and Autor (2011) identify also the routineness of work. They use the Occupational Information Network data (O*NET). This is the so-called successor of DOT. Similar to DOT, O*NET characterizes the task content of different occupations, but the dataset is much broader. Acemoglu and Autor (2011) measure routine intensity in four vast occupational categories: professional, managerial and technical occupations; clerical and sales occupations; production and operative occupations; and service occupations. The authors demonstrate that routine intensity is the highest in clerical and sales occupations, which represent routine cognitive occupations and in production and operative occupations, which represent routine manual occupations. As in the occupational categorization made by Autor et al. (2003), professional, managerial and technical occupations belong to non-routine cognitive occupations and service occupations to non-routine manual occupations.

Mitrunen (2013) exploits a similar method to measure routineness as Acemoglu and Autor (2011) and Autor et al. (2003). Acemoglu and Autor (2011) use the occupational classification at the four-digit level, but Mitrunen (2013) has changed the occupational classification to correspond to the Finnish classification, at the three-digit occupational level.

Mitrunen (2013) exploits the same index as Autor and Dorn (2013), namely the Routine Task Intensity (RTI). In addition, Mitrunen (2013) measures routineness based on two task components - routine cognitive and routine manual. This means that an occupation classifies as routine work if it requires relatively high levels of routine manual tasks, that is, finger dexterity or precision, or routine cognitive tasks like standards and strict rules.

The routineness in the RTI index is standardized to a mean that takes the value of zero with a cross-occupational standard deviation of one (Acemoglu and Autor, 2011). This means that 95 percent of occupations locate between the values 0.5 and -0.5. The value -0.5 means that an occupation requires relatively less routine work, whereas the value 0.5 means that an occupation requires relatively more routine work. The additional five percent either require substantial amounts of routine work or nearly no routine at all. The greater the value is, the more routine does an occupation consist of.

Mitrunen (2013) notices that especially occupations belonging to the middle-class, that is occupational classes 4, and 6-8, have a high level of at least one of these routine components. For instance, the RTI for *Clerks* (4) is 1.002 in routine cognitive and for *Skilled agricultural and fishery workers* (6) the RTI index is 1.4020 in routine manual. On the contrary, for *Service and care workers* (5) and *Legislators, senior officials, and managers* (1) the RTI index for both routine components are negative. The results are shown in table 3.

| | *Routine manual* | *cognitive* |
|---|---|---|
| *1. Legislators, senior officials, and managers* | *-0,5297* | *-0,6589* |
| *2. Professionals* | *-0,7846* | *-0,2306* |
| *3. Technicians and associate professionals* | *-0,5119* | *0,0527* |
| *4. Clerks* | *0,0796* | *1,002* |
| *5. Service and care workers* | *-0,658* | *-0,3071* |
| *6. Skilled agricultural and fishery workers* | *1,4020* | *-1,6609* |
| *7. Craft and related trade workers* | *0,8422* | *-0,1397* |
| *8. Plant and machine operators and assemblers* | *1,5429* | *0,4479* |
| *9. Elementary occupations* | *0,5184* | *-0,2331* |

*Table 3: Occupational routine intensity. Source: Mitrunen (2013).*

Mitrunen (2013) plots these results in a graph and demonstrates how routineness of occupations changes along the skill distribution. The horizontal axis shows occupations distributed in skill percentiles according to the average wage level in 1995. The vertical axis presents the routineness of occupations or the so-called RTI index, which Mitrunen calculate by the average value of the two routine components, routine cognitive and routine manual. The high intensity of routineness in middling jobs is highly detectable in figure 4. We observe that the routineness of occupations follows the exact same but reverse trend as the changes in employment shares in figure 1. This revelation is in line with our hypothesis of a shrinking middle-class caused by the routinization hypothesis.

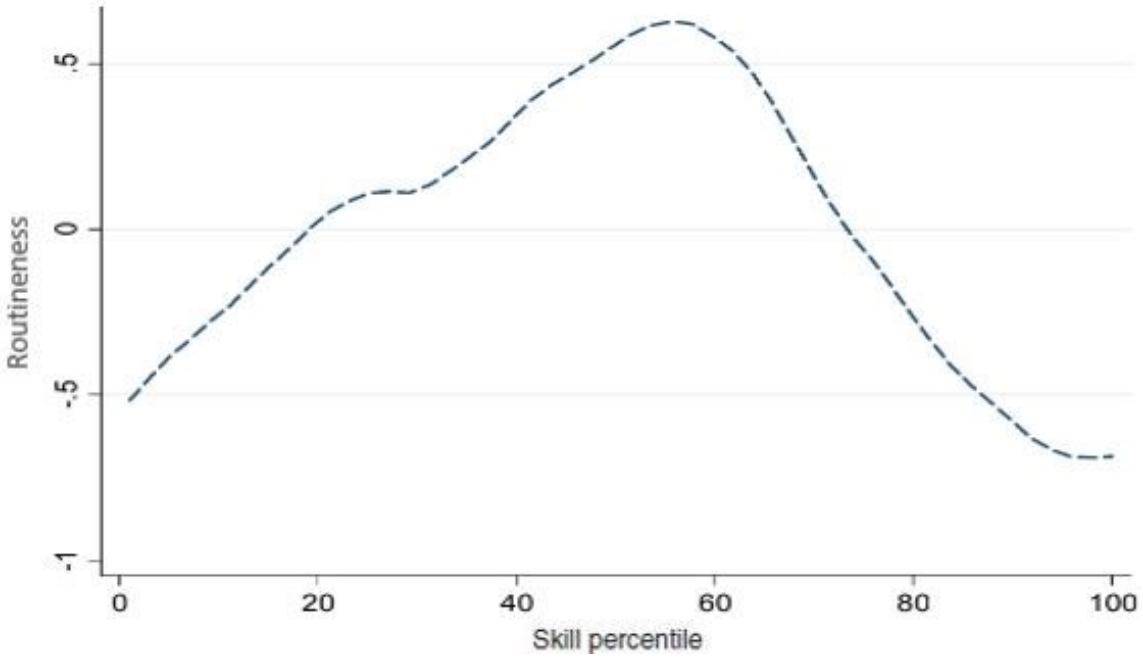


*Figure 4: The routineness of occupations along the skill distribution. Source: Mitrunen (2013).*

Thereby, one common divisor to the shrinking middle-class is the high intensity of routineness. However, even though these results are striking, we cannot claim that routine intensity of jobs solely causes polarization, although automation of routine intensive occupations is, to at least some extent, a significant explanatory factor for labor market polarization (Mitrunen, 2013).

## 3.3 Alternative explanations for polarization

As acknowledged, there is no unanimous explanation for labor market polarization. Even though the routine-biased technological change remains the most favored explanation, some research papers have begun to question its reliability as the reason behind polarization (Deming, 2017; Van Reenen, 2011; Michaels, Natraj, and Van Reenen, 2014; and Böckerman, Laaksonen, and Vainiomäki, 2016). For instance, the diminishing shares in the employment of some high-paying occupations are problematic to explain with the RBTC (Böckerman et al., 2016).

Alternative explanations for polarization are the rapid decline in computer prices induced by technological advancements, globalization, offshoring and the growing importance of social skills. However, economists agree that the routinization hypothesis remains, for now, the most plausible explanation and no other alternative can solely explain the polarization phenomenon as well as the RBTC (Autor et al., 2003; Goos and Manning, 2007).

### 3.3.1 Globalization and offshoring

For two decades, the structure of international trade has remarkably changed when firms have begun to outsource, or offshore parts of their production processes to other countries to save in production costs (Acemoglu and Autor, 2011). Offshoring refers to the trend of moving production, of mostly intermediate outputs outside of the home country, while still being able to supply the good or service at the home market (Blinder and Krueger, 2013).

Jobs producing intermediate outputs locate frequently in the middle of the wage and skill distribution. Acemoglu and Autor (2011) support this claim and find that offshoring of domestic jobs affects particularly middle-paying occupations. The reasons behind this are the task composition and routine intensity of middle-skilled jobs. Finger dexterity, precision and strict rules along with standards are easier to outsource than jobs requiring complex tasks and face-to-face interaction. Hence, offshoring does not usually threat high-paying, cognitive and low-paying, manual occupations (Böckerman and Vainiomäki, 2014). In addition, Böckerman and Vainiomäki (2014) demonstrate that employment shares have decreased especially in occupations with high routine intensity and offshorability.

Blinder and Krueger (2013) argue that offshorability of an occupation is a similar characteristic as, for instance, routine intensity. Offshorability implies that an occupation is not bound to a certain place and therefore, easily replaced to another location without having an impact on quality. Böckerman and Vainiomäki (2014) list the following occupations as easily offshorable: assembly line jobs, bookkeeping, and programming. All these occupations require at least some education and therefore, locate in the middle of the wage distribution. On the contrary, low-skilled workers like taxi drivers, cleaners, and barbers are more bounded to a specific location, and therefore, less likely

to become offshored. The same holds for high-paid jobs like corporate managers and lawyers. Böckerman and Vainiomäki (2014) propose that, based on this assumption, most of the industrial occupations are offshorable, whereas personal services are not.

Blinder and Krueger (2013) also study the effect of offshorability on jobs in the US. They find that approximately 25 percent of domestic jobs in the US are offshorable. Unlike Acemoglu and Autor (2011), Blinder and Krueger (2013) claim that not only routine tasks are offshorable, but also abstract and manual tasks that do not require human interaction. Blinder and Krueger (2013) also disagree with Böckerman and Vainiomäki (2014) and claim that routine intensive occupations do not correlate with offshorability more than others, less routinized occupations do.

There are significant differences and contradictions between these studies. This complicates the analysis of the impact of offshorability on polarization. However, we can assume that some of the changes in the employment shares and the wage structure are due to the changes in the structure of international trade and globalization. Nonetheless, offshorability and globalization as explanatory factors to polarization, play a relatively small role in comparison to the routine-biased technological change (Acemoglu and Autor, 2011; Goos et al., 2014).

### 3.3.2 The growing importance of social skills

Many studies claim that non-routine occupations survive the race against technology. This would imply that middle-paying occupations end up as losers, which is in accordance with the routine-biased technological change. However, there is evidence of the growing importance of social skills in the labor market (Deming, 2017). Technology alters not only the demand for education but also the demand for human skills. As a result, even non-routine jobs that do not require social skills and human interaction might become redundant (Deming, 2017). Therefore, the growing importance of social skills can, to some extent, explain the decline in employment shares of some high-paying and low-paying occupations.

Blinder and Krueger (2013), Weinberger (2014), and Deming (2017) study the impact of human interaction in the labor market. Weinberger (2014) demonstrates that occupations that demand a

high level of social skills as well as cognitive skills, experience significant growth in employment shares.[11] Deming (2017) supports this claim and argues that most of the employment growth since the 1980s occurs in occupations that require human interaction. As a result, the labor market rewards relatively more occupations demanding both social and cognitive skills. Hence, wage growth has been particularly strong in these occupations. Also, Pekkarinen, Sarvimäki, Terviö, and Uusitalo (2017) find that personality traits that affect earnings positively, such as sociability, have experienced an upward trend since 1980.[12]

Beaudry et al. (2016) present in their study evidence of a decreasing growth trend in the demand for educated workers since the 2000s. Blinder and Krueger (2013) find that non-routine cognitive occupations without human interaction are easily offshorable or substitutable with computer capital. Böckerman and Vainiomäki (2014) find similar results. They show that non-routine cognitive occupations can be offshored if the performance of these jobs do not require socials skills and the tasks can be broken down into smaller components. Böckerman and Vainiomäki (2014) mention analyzing roentgen pictures and programming as examples.

Deming (2017) takes this claim even further and argues that high-skilled, non-routine workers are as likely to become redundant as routine workers if they do not need social skills. One reason behind this evolution is technological improvements. New technology, such as information technology, allows computer capital to substitute occupations that locate higher up or lower down the skill distribution than before (Lu, 2015).

Even though computer capital can automate some complex non-routine occupations, there do not need to be fear of losing all occupations to technology. New occupations emerge, and task compositions of existing occupations change and broaden. Also, computers still find it difficult to interact with humans and automate occupations that require social skills. They are still unable to perform non-routine interaction with people, understand human emotions and react to different behavior. Thus, social skills function as barriers for computerization.

[11] For a more thorough analysis of why social skills are in high demand, see e.g. Weinberger (2014) and Deming (2017).
[12] Jokela et al. (2017) use data from the Finnish Defense Forces to examine the evolution of personality traits of Finnish men. The data covers approximately 79% of the population of Finnish men born during the years 1962 and 1976. The personality traits include self-confidence, sociability, leadership motivation, activity-energy, achievement striving, dutifulness, deliberation, and masculinity. All personality traits but masculinity have encountered steady increases and they predict higher earnings later in life.

# 4 Polarization of the Finnish labor market

As acknowledged in the earlier chapters, labor market polarization is present in almost every Western country. In this chapter, I will focus on the Finnish labor market. Labor market polarization in Finland is a well-researched topic. Asplund et al. (2011) examine polarization in the Nordic countries and Mitrunen (2013), Böckerman and Vainiomäki (2014) and Kauhanen and Maczulskij (2016) study polarization in Finland. This section compares also the labor market outcomes between Finland, Sweden, and Norway during the time interval 1996 to 2006. The time interval is chosen based on available research and to enable the cross-country comparison. The comparison of the labor markets in the Nordics is meaningful since their labor market structures remind of one another. Thus, a comparison with the US labor market would not be sensible regarding the substantial differences in labor market structures, such as unionization rates and exports dependency.

## 4.1 Job polarization in Finland

Mitrunen (2013), Böckerman and Vainiomäki (2014), and Asplund et al. (2011) find all evidence of labor market polarization in Finland. Böckerman and Vainiomäki (2014) study job polarization in Finland during the time periods 1995-2001 and 2002-2008. The authors use data from Statistics Finland on the structure of earnings to analyze changes in employment shares. They use working hours to examine how different occupational groups have evolved over time. They group all occupations by their median wages in ten deciles of equal size in ascending order in the year 1995 and 2002. Their findings detect labor market polarization from the mid-1990s to the financial crisis in 2008. The three highest deciles have increased their employment shares in both periods. In 2002-2008, both the first and the second decile have increased their shares, but only the first one in 1995-2001. The deciles in the middle of the distribution have encountered a significant decline. Thereby, they find evidence on what the authors call a “shrinking middle-class”. (Böckerman and Vainiomäki, 2014)

To measure polarization reliably through the years, the authors decided to examine the time period in two intervals due to changes in the occupational classification. The National Institute for Health and Welfare (Elinkeinoelämä) made some changes to the occupational classification in 2002. Thereby, the harmonization of the two time periods is not possible. (Böckerman and Vainiomäki, 2014)

Mitrunen (2013) exploits the same data as Böckerman and Vainiomäki (2014) in his study. He analyzes the time interval 1995-2008, but also from 2000-2008 to ensure that the depression in the 90s does not influence the results. Also, the results should reflect only the structural changes in the Finnish labor market. He measures polarization in 40 different occupational classes by dividing them into three groups based on their average wages in the year 1995, both at the two-digit level and three-digit level according to the ISCO-88 classification system. Mitrunen (2013) sorts the occupational classes into highest-paying occupations, middle-paying occupations, and lowest-paying occupations. The occupations remain in their assigned groups during the considered time interval, which enables reliable measurement of polarization.

The results show that employment shares in these occupational groups have evolved in the same directions as in the study of Böckerman and Vainiomäki (2014). Mitrunen (2013) presents that the middle-class has lost approximately 12 percentage points in employment shares in the labor market, whereas the high-skilled workers have profited nearly 7 percentage points and the low-skilled 3 percentage points in employment shares. Figure 5 presents the results. According to the structure of earnings data, the share of middle-paying jobs in the market dropped from 46 percent in 1995 to 34 percent in 2008. Mitrunen (2013) demonstrates that during this time, the middle-class lost nearly 300,000 jobs to lowest-paying or highest-paying occupations.

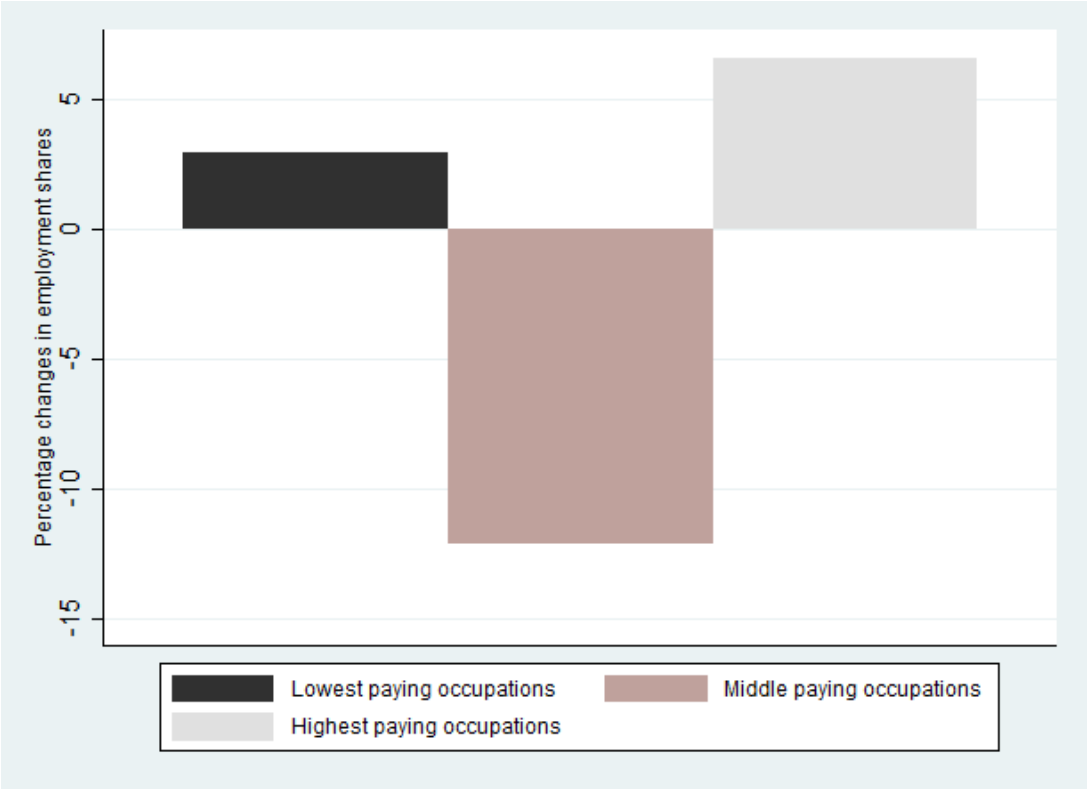


*Figure 5: Changes in employment shares in Finland over 1995-2008. Source: Mitrunen (2013).*

We notice in figure 5 that the Finnish labor market has encountered job polarization. Mitrunen (2013) detects a U-shaped curve along the polarization graph both during the time period 1995-2008, and the shorter period 2000-2008 at both the two-digit and three-digit level. The data Mitrunen uses, enables to observe, which occupations have gained or lost the most shares in employment. The occupations belonging to the highest-paying group at the two-digit level, which increased the most were *Physical, mathematical and engineering science professionals*, which belong to the class (21) and *Personal and protective services workers* (51) in lowest-paying occupations. Occupations belonging to the highest-paying group at the three-digit level that gained the most shares were *Computing professionals* (213) and *Architects, engineers and related professionals* (214). In the lowest-paying group, *Personal care and related workers* (513) increased the most according to Mitrunen (2013).

On the other hand, middle-paying occupations losing employment shares at the two-digit level were *Metal, machinery and related trades workers* (72) and *Machine operators and assemblers* (82). The corresponding losers at the three-digit level were *Numerical clerks* (412), *Cashiers, tellers and related clerks* (421) and *Electrical and electronic equipment mechanics and fitters* (724). Thereby,

the shrinking middle-class is mainly caused by a decline in industrial, manufacturing, and office jobs. However, even though there is evidence of a shrinking middle-class, Mitrunen (2013) argues that the labor force has increased by 300,000 employees during the observed period.

Also, Asplund et al. (2011) study the polarization phenomenon in Finland. In their study, they compare the results between the Nordic countries Finland, Sweden, and Norway to polarization in the US. Their data differs from the data used by both Mitrunen (2013) and Böckerman and Vainiomäki (2014). Asplund et al. (2011) exploit the Labour Force Survey from Statistics Finland to analyze polarization in the Finnish context. They study changes in employment shares over time from the mid-1990s to the mid-2000s by using data closest to the years 1996, 2001, and 2006. Thus, the authors use the Labour Force Survey for the years 1999, 2001, and 2005. Asplund et al. (2011) organize the occupations according to their median wages in the last year, thus using the same approach as Böckerman and Vainiomäki (2014), but different from Mitrunen (2013), who uses the average wage as an indicator.

Table 4 presents the changes in the employment shares across occupational classes over the time period 1999-2006. The changes are presented by percentage points, calculated at the two-digit level with standard errors in parentheses. According to the results, there has been significant growth in employment at the top end of the wage distribution in Finland. The employment share of the nine highest-paying occupations has increased in total by nearly five percent. This is mainly due to the increased demand of *Engineering science associate professionals* (31) and *Corporate managers* (12).

On the other hand, the middle-paying occupations have lost nearly four percent in employment shares over the past decade. The weakened demand of especially *Office clerks* (41) and *Metal, machinery and related trades workers* (72) have had a negative impact on the employment structure. These results are in accordance with the findings of Mitrunen (2013) since those occupations that he found as losers are subclasses to these occupations presented by Asplund et al. (2011).

| Two-digit occupation | Finland |
|---|---|
| *Nine top-paying occupations:* | |
| Corporate managers | 1.66 |
| | (0.251) |
| Physical, mathematical, engineering profess. | 0.19 |
| | (0.284) |
| Life science and health professionals | -0.91 |
| | (0.210) |
| Teaching professionals | -0.23 |
| | (0.219) |
| Engineering science associate professionals | 2.35 |
| | (0.248) |
| Other professionals | 0.21 |
| | (0.202) |
| Life science and health associate profess. | 1.09 |
| | (0.264) |
| Executive officers | -0.46 |
| | (0.358) |
| Teaching associate professionals | 0.74 |
| | (0.223) |
| | **4.64** |
| | **(0.61)** |
| *Nine middle-pay occupations:* | |
| Metal. machinery and related trades work | -2.14 |
| | (0.372) |
| Stationary-plant and related operators | 0.06 |
| | (0.165) |
| Extraction and building trades workers | 1.08 |
| | (0.246) |
| Models. salespersons and demonstrators | 1.19 |
| | (0.319) |
| Precision. handicraft. printing. etc. | -0.71 |
| | (0.146) |
| Drivers and mobile-plant operators | -0.1 |
| | (0.25) |
| Machine operators and assemblers | -0.09 |
| | (0.17) |
| Customer services clerks | -0.26 |
| | (0.165) |
| Office clerks | -2.92 |
| | (0.317) |
| | **-3.89** |
| | **(0.607)** |
| *Four lowest paying occupations:* | |
| Other craft and related trades workers | -1.38 |
| | (0.243) |
| Labourers in construction and manuf. | -0.02 |
| | (0.193) |
| Personal and protective services | 0.44 |
| | (0.383) |
| Service elementary occupations | 0.22 |
| | (0.226) |
| | **-0.74** |
| | **(0.502)** |

*Table 4: Changes in employment shares in Finland over 1999-2005. Source: Asplund et al. (2011).*

The results show that the lowest-paying occupations have not increased their shares as Mitrunen (2013) and Böckerman and Vainiomäki (2014) suggest. In this case, the lowest-paying occupations have lost employment shares by approximately one percent. However, Asplund et al. (2011) consider the class *Craft and related trades workers* (7) as a low-paying occupation, even though it is generally considered as a middle-paying occupation.[13] If we leave out class 7 from the lowest-paying occupations in table 4, we notice that this group has gained employment shares nearly one percent during the time period. The occupational classes *Personal and protective services workers* (51) and *Sales and services elementary occupations* (91) have contributed the most to the increase in this occupational group. In addition, when Asplund et al. (2011) expand their analysis of occupations to the three-digit level, polarization becomes more detectable in the Finnish labor market.

Obstbaum and Vanhala (2016) claim that the polarization of the Finnish labor market has become stronger during the 21st century. This is in line with the findings of Böckerman and Vainiomäki (2014), who found that only the first decile increased during the 90s, but in the 2000s, also the second decile increased. Thus, the U-shaped curve became more visible in the 2000s compared to the 90s.

Obstbaum and Vanhala (2016) also argue that the highest-paying occupations have increased their shares the most, whereas the lowest-paying occupations have not faced an equivalent growth as in other Western countries. Obstbaum and Vanhala (2016) observe that besides the globalization and digitalization trends, the Finnish labor market is affected by structural changes. For instance, Finland has encountered difficulties with its main industries, such as in forest, electricity and electrotechnical industries, and with the labor mismatch arising from the aging population. Maliranta (2013) also blames on the structural changes and mentions the arrival of multinational companies and offshoring as reasons for the polarization phenomenon. Maliranta (2013) claims that jobs have disappeared from all categories rather evenly, but new jobs have arisen mostly in highest-paying and lowest-paying occupations. Thereby, the arrival of new jobs might have, to at least some extent, affected labor market polarization.

Even though polarization is not as detectable in Finland as in other Western countries, there have been structural changes in the Finnish labor market. There is clear evidence of a winning category in all these studies examining polarization, namely the highest-paying occupational group.

[13] Compare the analysis of Mitrunen (2013), where he explains that the classes 4, 7, and 8 normally belongs to the middle-class since they require at least some education.

Furthermore, the middle-paying occupations come out as losers. However, there is not a clear understanding of the evolution of the lowest-paying occupational group. The results differ depending on the data, time period, and occupational classification used. Another thing worth mentioning is that these results of polarization differ also from the study made by Goos et al. (2014) presented in the second chapter. There are some significant differences between the studies, and I will go through them in more detail in section 4.3.

## 4.2 Wage polarization in Finland

Böckerman and Vainiomäki (2014) study polarization in the wage structure. They analyze how the real hourly wages have evolved during the time interval 1995-2008 in all deciles along the wage distribution. They found that the wage increased the most in those occupations where the starting level was the highest. Thereby, increasing the wage gap even further between low-paid and high-paid workers (Böckerman and Vainiomäki, 2014; Obstbaum and Vanhala, 2016). These results differ from the ones of Autor and Dorn (2013), who found the same U-shaped trend in the wage structure as in the employment structure in the US. Böckerman and Vainiomäki (2014) explain these differences by the skill-biased technological change. They argue that the changes in the wage structure in Finland are in accordance with the assumption of technological advancements increasing the marginal productivity of educated workers. As Asplund et al. (2011) explain, the Nordics have encountered in employment a shift from the skill-biased technological change to the routine-biased technological change, but in the wage structure rather a combination of these two technological changes. One alternative explanation for this is the relatively high wage rigidity and the compressed wage structures in the Nordic labor markets (Asplund et al., 2011). Thus, a corresponding wage polarization phenomenon as economists find in the US is not detectable in Finland.

As mentioned in chapter 2, wage and job polarization have different impacts on wage dispersion. According to the study of Böckerman and Vainiomäki (2014), both job and wage polarization have a negative impact on the wage dispersion in Finland, thus increasing the wage gap even further. These claims are supported by the study of Asplund et al. (2011), who find that wage growth has

been stronger in the upper parts of the wage distribution than in the intermediate and lower parts during 1996-2006.[14] They measure the relation between the wage in the highest decile and the first decile and compare the results with the ratio of the fifth and the first decile. According to the results, the ratio of the highest and first decile is higher than the ration of the fifth and first. Thereby, the strongest wage growth has occurred in occupations belonging to the highest-paying occupations, whereas wage growth has been rather flat in the other two categories. (Asplund et al., 2011)

## 4.3 Cross-country comparison and the Finnish labor market structure

As mentioned in chapter two, Goos et al. (2014) found no signs of labor market polarization in Finland. They only observed an increase in the highest-paying occupations and a decline in middle-paying occupations as well as lowest-paying occupations. This result contradicts with the findings of Mitrunen (2013) and Asplund et al. (2011). However, the degree of polarization might be much lower in Finland than in the other European countries Goos et al. (2014) include in their study. The reasons for this contradiction might either be the differences in data and time interval used, or the different labor market characteristics of Finland.

The time interval used by Goos et al. (2014) begins from 1993, thus considering the years during and immediately after the economic depression in Finland. This clearly affects the results, since the Finnish labor market was highly affected by the depression. In comparison, Asplund et al. (2011) begin their analysis from 1999 onwards, whereas Mitrunen (2013) includes the years 1995-2008 in his study. Mitrunen (2013) also examines a more stable time period, 2000-2008, to ensure that the depression does not affect the results. According to Statistics Finland, the worst unemployment year was indeed 1994 and by this year, Finland had lost close to 400,000 employees (Statistics Finland, 2015).

[14] Asplund et al. (2011) demonstrate how the occupational wages have changed during the period 1996-2006 by measuring the deviations in the growth of the median wage relative to the average wage in every 22 occupational classes. The results are visible in table A3 in the appendix. We notice that the wage growth is strongest in the highest-paying occupations and weakest in the middle-paying occupation. However, the wage growth of the lowest-paying occupations is quite modest as well, which implies that the Finnish labor market has not faced a similar wage polarization phenomenon as the US (see Autor and Dorn, 2013).

Mitrunen (2013) also points out that the data used by Goos et al. (2014) is not as suitable to measure polarization as the data used by Mitrunen. He implies that the European Union Labor Force Survey is not as descriptive as the data from Statistics Finland on the structure of earnings. Additionally, the occupational classification system differs between the studies. Goos et al. (2014) exploit in their analysis the two-digit occupational level when examining the changes in the employment shares. Both Asplund et al. (2011) and Mitrunen (2013) use, on the other hand, both the two-digit and the three-digit level and notice that the polarization trend is more detectable when the classification is more precise. That is when using the three-digit occupational level. The occupational classification system affects the results and alters them to some extent. So, if Goos et al. (2014) would have used a more precise classification, they might have received different results.

Furthermore, Goos et al. (2014) use the ISCO-88 occupational classification system in their study. Although the classification system is built on international standards, there are country-specific differences that might affect the results. For instance, some occupations do not necessarily belong to the same group in every country. When comparing cross-country polarization rates, it is crucial to consider differences between the occupational classes. Mitrunen (2013) takes into consideration these cross-country differences by dropping some occupations from the analysis to make the study coherent. For instance, the occupational class *Life science and health associate professionals* (32) belongs in ISCO-88 to the highest-paying occupations. However, in Finland, this class includes occupations that belong mostly to either lowest-paying or middle-paying occupations. In order to facilitate the measurement of polarization in Finland, Mitrunen drops this occupational class from his study. Another reason for dropping this class is because of some of the occupations belonging to class 32 changes from being a low-paying occupation to a middle-paying occupation over the observed time period. Occupations that belong to subclasses of class 32 are *Life science technicians and related associate professionals* (321) such as *Agronomy and forestry technicians* (3212) and *Farming and forestry advisers* (3213), *Modern health associate professionals (except nursing)* (322) like *Dental assistants* (3225) and *Physiotherapists and related associate professionals* (3226), and *Nursing and midwifery associate professionals* (323) (ILO, 2004).

Figure 6 presents the different results by Goos et al. (2014), Mitrunen (2013) and Asplund et al. (2011). I have also added a modified Asplund et al. (2011), which is identical to the original in all aspects but one. I have switched the occupational class *Craft and related trades workers* (7) from being a low-paying occupation to a middle-paying occupation. We observe that different methods

in analyzing polarization results in different outcomes. However, the changes in the employment shares are in all studies biased in favor of highest-paying occupations, whereas the middle-class ends up as a loser.

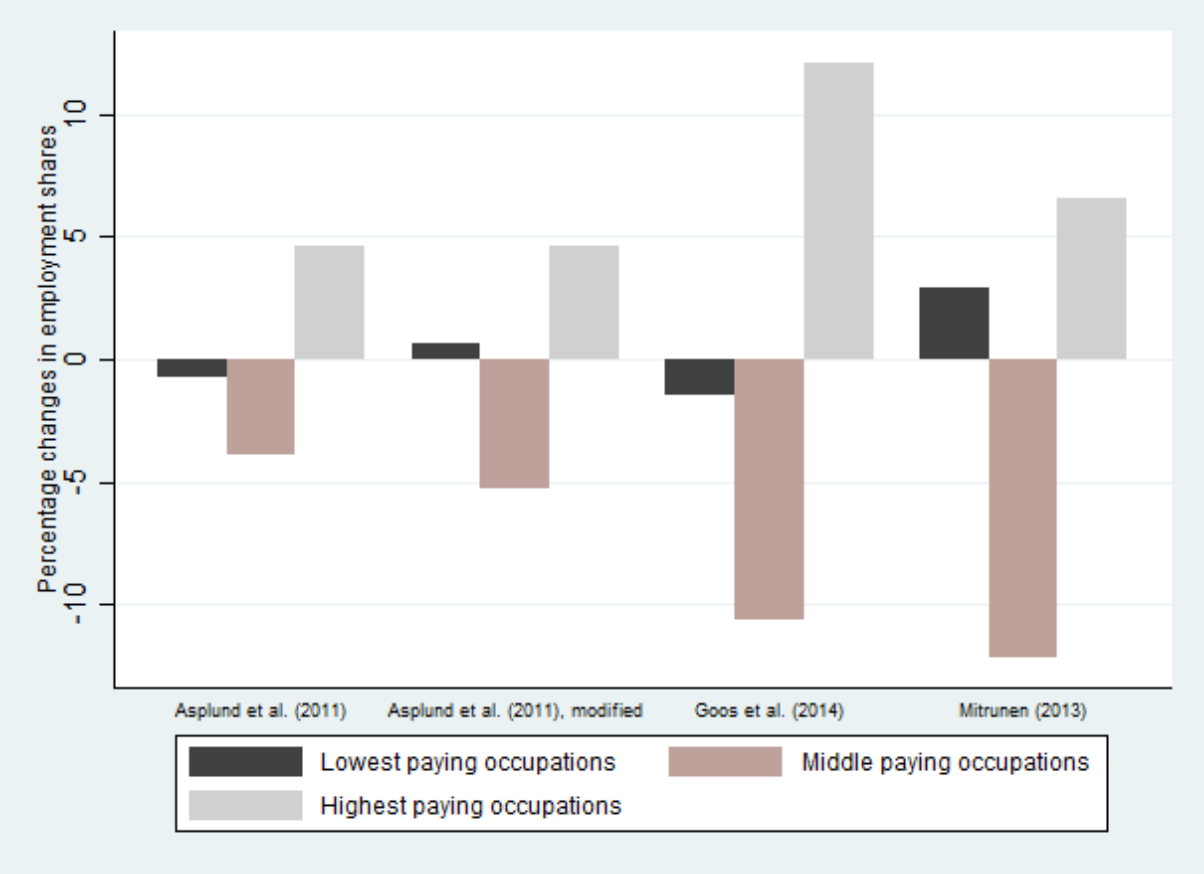


*Figure 6: Comparing studies on polarization in the Finnish labor market. Source: Goos et al. (2014); Mitrunen (2013); Asplund et al. (2011).*

The Finnish labor market structure is the latter explanation for the contradiction between the studies. The Finnish labor market structure differs from many Western countries and might, to at least some extent, explain the differences.

### 4.3.1 Labor market structure in Finland

When comparing the degree of polarization between countries, it is crucial to consider the labor market structure of different countries. Finland is a small, trade-dependent open economy. The smaller and more open a country is, the more vulnerable it is to globalization. A country vulnerable to globalization has a higher probability to become affected by structural changes caused by it, for instance, factors affecting the labor demand side, such as technological improvements (Asplund et al., 2011). Finland has a strong position in both information and communication technologies as well as research and development. These technological advancements reduce the amount of middle-skilled jobs due to the routinization hypothesis, which, on the other hand, results in polarization.

Another feature quite characteristic to the Nordics, and thereby to the Finnish labor market, is the relatively high unionization rate. Labor unions have a higher negotiation power in the Nordics in comparison to the UK and the US. As a result, these countries with higher unionization rates have proportionately more rigidity in wages and inflexible labor markets. (Asplund et al., 2011) Hence, Asplund et al. (2011) find in their analysis that the two least unionized countries in their study, United States and Norway, have the most U-shaped curves in the polarization graphs, thereby, face the strongest degree of polarization. Finland and Sweden, on the other hand, face a milder change in employment shares. Boldt and Laine (2001) argue that to increase the flexibility and adaptation of the labor market and to enable structural changes, it is necessary to diminish the power of labor unions.

The relatively high unionization rate hinders the labor market to change accordingly to the demand. It makes the market less flexible and adaptable to shocks facing the labor market. This can lead to a slightly less polarized labor market, at least in the short-run, since firms cannot fire and hire new people as they please. In addition, labor unions can affect the wage structure and thereby, influence the wage level of firms. In other words, unions do not let firms decide on salaries due to minimum wage rates or hourly wages, or by collective bargaining agreements that set industry-specific minimum wages. The latter system sets the framework for labor markets in Finland.

Thereby, the differed degree of polarization in Finland among the studies might also depend highly on the differences in the labor market structures of countries, such as size, unionization rate, and overall wage structure. All these factors either allows or hinders the labor market from flexible

shifting, and thus affect the degree of polarization. However, according to Mitrunen (2013), the most plausible reason for the differences in results regarding the degree of polarization is the data and time interval used. Nevertheless, Mitrunen (2013) do not discuss the possible impact of the labor market structure on the results.

## 4.4 Labor market polarization in the Nordics according to Asplund et al. (2011)

Asplund et al. (2011) study labor market polarization in the Nordic countries Finland, Sweden, and Norway. In this section, I compare the labor market outcomes in these countries from the mid-1990s to the mid-2000s.

The authors use the Labour Force Survey for the years 1999, 2001, and 2005 to investigate polarization in Finland. For the Norwegian labor market, they use data from Statistics Norway on wage statistics for the years 1997, 2000 and 2006, and for Sweden, data from Statistics Sweden during 1997, 2001 and 2006. In all years but for Sweden in 1997, the occupation data of occupational codes and information on earnings and working hours are comparable. Also, the authors try to collect data from every country from a year closest to 1996, 2001 and 2006. Thereby, the data they use is not necessarily from the same year in all countries. These limitations need to be taken into account when comparing the results.

Asplund et al. (2011) investigate changes in the employment and wage structure in these countries over 22 occupational classes at the two-digit level.[15] The occupational classes are organized into three groups based on their median wage level closest to the year 2006. Even though the labor market structures are similar in the Nordics, there are some distinctive differences in the occupational classification. For instance, in Sweden, *Stationary-plant and related operators* (81) and *Customer services clerks* (42) should belong to the lowest paying occupations instead of the middle-

[15] Asplund et al. (2011) also investigate labor market polarization at the three-digit level, but in this section, I will only go through their results based on the two-digit level. However, when the authors expand their occupational classification to the three-digit level, polarization becomes more detectable in all countries.

pay occupations according to the median wage (Asplund et al., 2011). In Norway, on the other hand, *Models, salespersons and demonstrators* (52) should belong to the lowest-paying occupations.[16]

According to Asplund et al. (2011), changes in the employment shares have evolved similarly in the Nordic countries. In the upper part of the distribution, the occupations that have gained the most employment shares in Sweden are *Corporate managers* (12), as in Finland, but also *Other professionals* (24). In Norway the corresponding occupational classes are *Engineering science associate professionals* (31), as in Finland, and *Other professionals* (24). As for the lowest-paying occupations, each country has faced growth in the same classes, namely *Personal and protective services workers* (51) and *Sales and services elementary occupations* (91).

Almost every occupational class in the middle-paying occupations have evolved in the same manner in each country. The two classes that lost the most shares during the time period are *Office clerks* (41) and *Metal, machinery and related trades workers* (72). In Finland and Norway, the middle-paying occupations have in total declined 3.89 and 5.48 percent respectively. In Sweden, on the other hand, middle-paying occupations have increased by 1.19 percent. However, the employment growth in the highest-paying and lowest-paying occupations has been more significant. The growth rate in the upper part of the wage distribution was 4.88 during 1997-2006 and for the lower part 2.14. In Norway, the growth rate of employment shares in the highest-paying occupations was 3.3, whereas in Finland 4.64. The corresponding growth rate for Norway in the lowest-paying occupations was 2.19 when in Finland the lowest-paying occupations declined by 0.74.

At the two-digit level, polarization is not detectable in Finland and Sweden[17]. However, in Finland, this depends on the fact that the occupational class, *Craft and related trades workers* (7), is considered as a low-paying occupation. Sweden, on the other hand, encounters increasing employment shares in all categories, but more substantial growth in highest-paying and lowest-paying occupations. In Norway, the degree of polarization is the strongest. One explanation for this might be the lower unionization rate in Norway compared to the two other countries. However, the pattern of labor market polarization is highly similar in all three countries.

[16] See table A1 in appendix.
[17] See table A2.

# 5 What happens to the shrinking middle-class?

We have seen the middle-skilled workers end up as losers due to labor market polarization. When the employment shares of the middle-paying occupations decline, the middle-class workers affected by polarization, tend to relocate in the labor market. This section describes the effect of polarization and the routine-biased technological change on individuals that are forced to occupational reallocation.

Cortes (2016) examines the impact of routine-biased technological change on mobility and reallocation of work in the US. The paper exploits the Panel Study of Income Dynamics over the years 1976-2007 to study the occupational transition trends during these three decades. It also enables studying wage changes of routine workers both in the short-run and long-run. The data allows studying individuals from various cohorts by their social behavior, earnings, and economic health. There has been little literature on the effect of polarization on the individual worker, so, Cortes (2016) tries to fill this gap.

The data allows studying individual workers over time in occupations at the three-digit level. Cortes (2016) divides occupations into three groups following Acemoglu and Autor (2011): non-routine manual, routine, and non-routine cognitive.[18] In his study, Cortes (2016) use a general equilibrium model similar to the one presented in chapter 3.2. He separates between low-ability routine workers and high-ability routine workers. The model by Cortes (2016) shows that middle-class workers in low-skilled routine jobs, forced to find a new job, tend to switch to non-routine manual jobs. Workers in routine jobs demanding more skills, on the other hand, tend to switch to non-routine cognitive tasks. (Cortes, 2016)

The probability of occupational transition across high-ability and low ability routine workers differs. The high-ability routine workers are at the end more likely to reallocate than low-ability routine workers. However, the probability of occupational transition encounters a U-shaped curve along the skill distribution. As a result, mobility is higher at the ends of the distribution and less mobile in the

[18] These groups correspond to the groups I have mentioned earlier as lowest-paying, middle-paying, and highest-paying occupations. The author argues that this classification differs from the one I follow since it does not require to separate between low-, middle-, and high-skilled workers, but rather takes into account task requirements and task contents. However, based on his classification, the occupations he groups in non-routine manual correspond to those in lowest-paying occupations, routine to middle-paying occupations, and non-routine cognitive to highest-paying occupations.

middle. The author demonstrates that the probability of reallocating from routine jobs to non-routine cognitive occupations increased after the 1990s from 10.4 to 13.4 percent, whereas the probability of switching to a non-routine manual occupation changed from 1.9 (before 1990s) to 3.0 percent (after 1990s). Thus, the probability of reallocating of high-ability workers is higher than the probability of low-ability workers. Furthermore, the probability of occupational transition is increasing but suggests that the reallocation of routine workers in the middle-class to the lowest-paying occupations has not been that significant. (Cortes, 2016) Cortes (2016) also demonstrates that according to his study, the sharp decline in middle-class jobs almost completely depends on the occupational reallocation of employed routine workers to non-routine jobs. On the other hand, he shows that the new entry of unemployed workers tends to increase the share of routine jobs.

One important factor influencing the re-employment of workers is the degree of mobility in the labor market (Obstbaum and Vanhala, 2016). Mobility, in this case, refers to either upward or downward mobility of workers along the wage and skill distribution. Kambourov and Manovskii (2008) find evidence of increasing occupational mobility in the US from the end of the 1960s to the end of the 1990s. Additionally, there might be unequal mobility opportunities for different skilled workers. High-ability workers tend to have more possibilities in finding a new job with wages higher than average, whereas low-ability workers tend to find jobs with wages lower than average (Groes, Kircher, and Manovskij, 2010). Groes et al. (2010) also find that occupational mobility is facing a similar U-shaped curve as job polarization along the wage distribution, implying that workers at the fringes of the distribution are more likely to switch occupations than those lying in the middle.

As the model by Autor et al. (2003) presented in chapter 3.2 suggests, workers choose their inputs according to their comparative advantage. Also, Gibbons et al. (2005) share this view and find empirical evidence of occupational sorting being influenced by comparative advantages. Thereby, the most skilled individuals will find themselves in non-routine cognitive occupations, middle-skilled in routine occupations, and low-skilled in non-routine manual occupations. These comparative advantages in different skills can be highly valuable in the labor market when there is a need for reallocation. For instance, an individual who possesses cognitive skills has better possibilities finding another job at the upper part of the wage and skill distribution, or in high-ability routine jobs in the middle of the distribution (Cortes, 2016). Low-ability routine workers, on the other hand, tend to shift downwards on the skill and wage distribution.

Another finding by Cortes (2016) is that workers who remain in routine jobs will encounter a substantial decline in real wages in comparison to those who either stay in non-routine cognitive or non-routine manual jobs. Cortes (2016) finds that an individual worker staying in a routine occupation will face a 6.2 percent smaller wage growth than stayers in either non-routine occupational group, over a four-year time period. When comparing these results to a ten-year time period, the routine occupations face a 10.5 percent smaller wage growth. These results are statistically significant at the 1 percent level and imply that the middle-class workers are relatively worse off than those workers at the ends of the wage distribution. (Cortes, 2016)

In addition, Cortes (2016) studies the impact of RBTC on wage changes of routine workers who reallocate to non-routine occupations. When a worker switches to a non-routine manual job, the wage level initially decreases, but in the long-run increases significantly. Thus, in the short-run, over a two-year time period, the worker switching from a routine job encounters a wage change 14 percent lower than those remaining in a routine job. However, in the long-run, over a ten-year time period, the switcher experiences a wage change 5 percent higher than those staying. Contrarily, those routine workers switching to non-routine cognitive occupations encounter a nearly similar, but positive wage growth both in the short-run and the long-run. Over a two-year time period, the wage growth is 12 percent higher than for those remaining in routine jobs. Over a ten-year time period, the corresponding wage growth is 14 percent. These results are statistically significant at the 1 percent level. (Cortes, 2016)

Cortes (2016) finds that routine-biased technological change affects workers with different skill levels differently. He claims that most high-ability routine workers shift to high-skilled, non-routine cognitive jobs, whereas low-ability routine workers shift to less skilled, non-routine manual jobs. However, the RBTC is argued to have no impacts on occupational sorting of workers who already work in these non-routine occupations (Cortes, 2016).

## 5.1 Middle-class occupational mobility in Finland

Kauhanen and Maczulskij (2016) investigate in their research paper where the middle-class workers go after losing their jobs during the years 1995-2009 in Finland. Contrary to Cortes (2016), Kauhanen

and Maczulskij (2016) separate routine workers into two groups based on the classification made by Autor et al. (2003): routine cognitive and routine manual workers.

Routine workers can end up in different labor market positions, such as remain in routine jobs, switch to either non-routine cognitive or non-routine manual jobs, become entrepreneurs or unemployed, or exit the labor market (Kauhanen and Maczulskij, 2016). To examine what happens to the shrinking middle-class, the authors use the Finnish Longitudinal Employer-employee Data (FLEED). This data includes people participating in the labor force in Finland, aged 15 to 70, and shares information on basic characteristics, civil status, education, earnings, and labor market participation. The occupational classification used is based on the ISCO-system at the two-digit level.

Kauhanen and Maczulskij (2016) take into consideration those individuals who worked in a routine cognitive or routine manual job in 1995. The authors investigate these individuals until the year 2009. According to the results, a great number of routine workers remain in routine jobs. Moreover, they find that those routine workers with cognitive abilities have a better chance to reallocate themselves and find a new job at the top end of the wage and skill distribution. Contrary, routine workers with manual abilities will more likely shift downwards the distribution and end up in lowest-paying occupations. These results are in accordance with Cortes (2016).

Kauhanen and Maczulskij (2016) claim that routine manual workers have a harder time finding a new job than routine cognitive workers. Thereby, they have a higher probability of ending up as unemployed or exiting the labor force. In addition, Asplund, Kauhanen, and Vanhala (2015) find that routine cognitive workers, such as *Office clerks* (41) and *Customer services clerks* (42), have good opportunities in occupational reallocation after losing a job. Industry workers, or non-routine manual workers, on the other hand, become more easily unemployed or switch downwards to the bottom-end of the wage and skill distribution (Asplund et al., 2015). However, Cortes (2016) does not find significant differences between routine workers and the two non-routine workers in the probability of becoming more likely unemployed or exiting the labor force.

# Conclusion

The purpose of this thesis is to show that there has been a rupture in the employment shares and in the wage structure in the Western countries, which favors highest-paying and lowest-paying occupations at the expense of middle-paying occupations. This phenomenon is called labor market polarization and it has been vastly studied since the beginning of 1980. I examine in this thesis labor market polarization in the Western countries over the time period 1980-2010, with a special focus on the Finnish labor market. In this section, I present the main findings of labor market polarization.

The interest in this topic arose from the increasing wage inequality between educated and non-educated workers detected at the end of the 1970s (Katz and Autor, 1999), and the first research on polarization was made in the US (Acemoglu, 1999). Polarization is detectable in almost every Western country. However, the degree of polarization varies across countries. For instance, Goos et al. (2014) examine labor market polarization in 16 Western European countries in 1993-2010 and find evidence of a shrinking middle-class and increasing employment shares in highest-paying and lowest-paying occupations. They find that the middle-paying occupations declined 9.3 percent during the observed time period, whereas the highest-paying and lowest-paying occupations increased their employment shares by 5.6 percent and 3.7 percent respectively. When expanding their study to examine polarization in each country, they found that in all countries, the employment shares of middle-paying occupations declined, and the employment shares of highest-paying occupations increased. In all but two countries, namely Finland and Luxembourg, the lowest-paying occupations encountered an increase in employment shares. Goos et al. (2014) demonstrate that polarization has been particularly strong in the UK and the US, whereas in Finland and Luxembourg rather modest.

In addition, they examine, which occupations have been affected the most by the changes in the employment structure. They observe that the highest-paying occupations that gained most employment shares are *Corporate managers* (12), *Physical, mathematical and engineering science professionals* (21) and *Other professionals* (24), whereas *Personal and protective services workers* (51), and *Sales and services elementary occupations* (91) increased their shares the most in the lowest-paying occupations. On the contrary, middle-paying occupations experiencing the greatest loss are *Office clerks* (41), *Metal, machinery and related trades workers* (72), and *Machine operators and assemblers* (82).

In addition, Autor and Dorn (2013) and Cortes (2016) find evidence of labor market polarization in the US. Autor and Dorn (2013) show that employment growth has been strong in especially the upper and lower parts of the wage distribution. On the other hand, the middle-class has lost employment shares. Cortes (2016) find similar results. He shows that the middle-paying occupations have faced a substantial loss in employment shares, whereas the low-paying and high-paying occupations have compensated this decrease by increasing their employment shares. However, both Autor and Dorn (2013) and Cortes (2016) argue that the recent growth in employment shares has been increasing the most at the bottom end of the wage distribution. Autor and Dorn (2013) claim that between 1980 and 2005, the employment shares of low-educated workers, particularly, in service occupations, increased by approximately 30 percent.

Mitrunen (2013), Böckerman and Vainiomäki (2014), and Asplund et al. (2011) study polarization in the Finnish context. Mitrunen (2013) measures polarization in 40 different occupational classes in 1995-2008. He finds that the middle-paying occupations declined by approximately 12 percent, whereas the highest-paying and lowest-paying occupations increased their employment shares by 7 percent and 3 percent respectively. Also, during this time, the middle-class lost nearly 300,000 jobs (Mitrunen, 2013). The results by Böckerman and Vainiomäki (2014) are in accordance with the results by Mitrunen (2013). They find that the two upper and lower deciles in the wage distribution have experienced growth in employment shares when the middle-class has simultaneously declined.

Mitrunen (2013) also study, which occupations are affected the most by the changes in the employment structure. The occupations belonging to the highest-paying occupations that increased the most are *Physical, mathematical and engineering science professionals* (21) and *Personal and protective services workers* (51) in lowest-paying occupations. On the contrary, middle-paying occupations losing employment shares are *Office clerks* (41), *Metal, machinery and related trades workers* (72) and *Machine operators and assemblers* (82). These results are, on the other hand, in accordance with the results by Goos et al. (2014).

Asplund et al. (2011) study labor market polarization in Finland, Sweden, and Norway. They show that the changes in the employment shares have evolved similarly in the Nordic countries. In the upper part of the distribution, the occupations that have gained the most employment shares are *Corporate managers* (12), *Other professionals* (24), and *Engineering science associate professionals* (31). As for the lowest-paying occupations, each country has faced growth in the same occupational

classes, namely *Personal and protective services workers* (51) and *Sales and services elementary occupations* (91). However, middle-paying occupations that experience the greatest loss are *Office clerks* (41) and *Metal, machinery and related trades workers* (72). The cross-country average employment growth in highest-paying occupations is 4.3 percent, in lowest paying occupations 1.2 percent and in the middle-paying occupations declined by 2.7 percent[19]. Thereby, polarization is detectable in the Nordic countries.

Recent research on labor market polarization has begun to separate between job and wage polarization. Autor and Dorn (2013) show that changes in the wage structure have experienced a similar U-shaped pattern as the employment structure. Wage growth has favored the top end of the distribution the most, whereas the bottom end has faced a modest increase. The middle-class has encountered a much weaker wage growth. However, according to Böckerman and Vainiomäki (2014), Finland has not experienced a corresponding wage polarization phenomenon as the US. On the contrary, they find that the wage increased the most in those occupations where the starting level was the highest. Thereby, the strongest wage growth has occurred in occupations belonging to the highest-paying occupations, whereas wage growth has been rather flat in the other two categories. (Asplund et al., 2011) One alternative explanation for the differences between wage growth in these countries is the differences in the labor market structures, such as size, unionization rate, and overall wage structure. For instance, the unionization rate is relatively high in Finland. As a result, countries with higher unionization rates have proportionately more rigidity in wages and inflexible labor markets (Asplund et al., 2011). This pattern of changes in the wage structure we detect in Finland have a negative impact on the wage dispersion in Finland, which increase the wage gap even further.

This thesis also aims to explain the reasons behind polarization and suggests that the most favored explanation for labor market polarization is the routinization hypothesis or the so-called routine-biased technological change. This idea was introduced by Autor et al. (2003) and suggest that technology substitutes for routine work and complements high-skilled non-routine work. Thereby, the continuously falling price of computer capital and the rapid technological improvements lead to an increase in demand for education, but to a decline in routine jobs, which are replaced by computers. Hence, the more routine work an occupation requires, the more applicable it is for

[19] See table A2.

automation. Mitrunen (2013) shows that repetition is typical for middle-paying occupations and observes that routine intensity of occupations increases in the middle of the skill distribution and decreases at the fringes. Thereby, one common divisor of the shrinking middle-class is the high routine intensity. Moreover, Autor and Dorn (2013) show that most of the middle-class workers in routine tasks, substituted by computer capital, relocate to the bottom end of the wage distribution, especially to service occupations that are proven hard to replace with computers. These structural changes explain well the shrinking middle-class and the observed changes in the employment structure. However, there is yet no unanimous explanation for polarization and I go through briefly some alternative explanations for polarization as well.

There is clear evidence of a winning category in all these studies examining polarization, namely the highest-paying occupational group. Furthermore, the middle-paying occupations come out as losers. However, Beaudry et al. (2016) find evidence of 'de-skilling', which implies that high-skilled workers shift down to the middle parts of the wage distribution and middle-skilled workers shift down to the lower parts. They find that the demand for high-skilled workers has declined during the 21st century. An explanation for this is the maturity of technological improvements but also the evolution of computer science such as Artificial Intelligence and machine learning (Böckerman and Vainiomäki, 2014).

The impact of the 'de-skilling' phenomenon and the increased demand for social skills on polarization are areas applicable for future research. There are implications of a growing demand for occupations that require non-cognitive skills like social skills (Deming, 2017) and one interesting aspect is the differences in social skills between countries. Also, the future evolution of labor market polarization is of great importance, as for future implications for wage dispersion, the employment structure, and the demand for education and human skills. A highly educated country like Finland with great resources for research and development has great terms for growth. To diminish the negative impacts of the recent changes in the employment and wage structure and support growth, Finland should support the emergence of new high-skilled jobs and promote education. By ensuring a high level of education we can diminish the negative impacts of the structural changes on the deadweight loss of individual workers caused by for instance unemployment or wage changes.

However, even though there is a fear of losing the race against the machine, there are continuously emerging new occupations, and task compositions of existing occupations change and broaden. In addition, even though computers result in some occupations becoming redundant, the labor force

has not diminished in the long run. For instance, Mitrunen (2013) shows that, although the middle-class is shrinking, the labor force has increased by 300,000 employees in Finland during the years 1995-2008.

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# *Appendix*

*Table A1: Occupational classes ranked into deciles at the two-digit level according to their median wage level closest to the year 2006. Source: Asplund et al. (2011).*

| **Two-digit occupation** | **Finland** | **Norway** | **Sweden** |
|---|---|---|---|
| *Nine top-paying occupations:* | | | |
| Corporate managers | 10 | 10 | 10 |
| Physical, mathematical, engineering profess. | 9 | 10 | 10 |
| Life science and health professionals | 8 | 9 | 9 |
| Teaching professionals | 10 | 9 | 8 |
| Engineering, science associate professionals | 9 | 8 | 8 |
| Other professionals | 7 | 7 | 9 |
| Life science and health associate profess. | 5 | 6 | 7 |
| Executive officers | 6 | 7 | 7 |
| Teaching associate professionals | 7 | 8 | 6 |
| *Nine middle-pay occupations:* | | | |
| Metal. machinery and related trades work | 6 | 5 | 5 |
| Stationary-plant and related operators | 8 | 6 | 1 |
| Extraction and building trades workers | 3 | 5 | 6 |
| Models, sales and demonstrators | 4 | 1 | 6 |
| Precision, handicraft, printing, etc. | 5 | 6 | 3 |
| Drivers and mobile-plant operators | 3 | 2 | 5 |
| Machine operators and assemblers | 4 | 3 | 4 |
| Customer services clerks | 6 | 3 | 1 |
| Office clerks | 2 | 4 | 3 |
| *Four lowest paying occupations:* | | | |
| Other craft and related trades workers | 1 | 4 | 4 |
| Labourers in construction and manufacturing | 2 | 1 | 2 |
| Personal and protective services | 1 | 2 | 2 |
| Service elementary occupations | 1 | 1 | 1 |

*Table A2: Changes in employment shares over 1996-2006. Source: Asplund et al. (2011).*

| Two-digit occupation | Finland | Norway | Sweden |
|---|---|---|---|
| *Nine top-paying occupations:* | | | |
| Corporate managers | 1.66 | -0.3 | 1.18 |
| | (0.251) | (0.051) | (0.016) |
| Physical, mathematical, engineering profess. | 0.19 | -0.89 | 0.58 |
| | (0.284) | (0.035) | (0.013) |
| Life science and health professionals | -0.91 | 0.25 | 0.62 |
| | (0.210) | (0.020) | (0.010) |
| Teaching professionals | -0.23 | 0.39 | 0.15 |
| | (0.219) | (0.035) | (0.015) |
| Engineering science associate professionals | 2.35 | 2.28 | -0.09 |
| | (0.248) | (0.040) | (0.016) |
| Other professionals | 0.21 | 2.02 | 1.57 |
| | (0.202) | (0.021) | (0.012) |
| Life science and health associate profess. | 1.09 | 0.73 | 0.02 |
| | (0.264) | (0.051) | (0.019) |
| Executive officers | -0.46 | 0.04 | 0.75 |
| | (0.358) | (0.041) | (0.010) |
| Teaching associate professionals | 0.74 | -1.22 | 0.1 |
| | (0.223) | (0.082) | (0.035) |
| | **4.64** | **3.3** | **4.88** |
| | **(0.61)** | **(0.08)** | **(0.03)** |
| *Nine middle-pay occupations:* | | | |
| Metal. machinery and related trades work | -2.14 | -2.12 | -0.84 |
| | (0.372) | (0.046) | (0.014) |
| Stationary-plant and related operators | 0.06 | 0.89 | -0.14 |
| | (0.165) | (0.021) | (0.008) |
| Extraction and building trades workers | 1.08 | 0.47 | 0.95 |
| | (0.246) | (0.036) | (0.015) |
| Models. salespersons and demonstrators | 1.19 | 0.7 | 1.57 |
| | (0.319) | (0.033) | (0.014) |
| Precision. handicraft. printing. etc. | -0.71 | 0.03 | -0.16 |
| | (0.146) | (0.012) | (0.005) |
| Drivers and mobile-plant operators | -0.1 | -0.05 | 0.88 |
| | (0.25) | (0.03) | (0.01) |
| Machine operators and assemblers | -0.09 | -2.2 | -0.32 |
| | (0.17) | (0.038) | (0.017) |
| Customer services clerks | -0.26 | -0.38 | 0.38 |
| | (0.165) | (0.02) | (0.009) |
| Office clerks | -2.92 | -2.82 | -1.13 |
| | (0.317) | (0.052) | (0.019) |
| | **-3.89** | **-5.48** | **1.19** |
| | **(0.607)** | **(0.082)** | **(0.034)** |
| *Four lowest paying occupations:* | | | |
| Other craft and related trades workers | -1.38 | -0.32 | 0.02 |
| | (0.243) | (0.018) | (0.004) |
| Labourers in construction and manuf. | -0.02 | -1.4 | -0.33 |
| | (0.193) | (0.024) | (0.008) |
| Personal and protective services | 0.44 | 3.16 | 1.4 |
| | (0.383) | (0.035) | (0.025) |
| Service elementary occupations | 0.22 | 0.75 | 1.05 |
| | (0.226) | (0.019) | (0.014) |
| | **-0.74** | **2.19** | **2.14** |
| | **(0.502)** | **(0.048)** | **(0.029)** |

*Table A3: Changes in relative occupational wages during 1999-2005. Source: Asplund et al. (2011).*

| **Two-digit occupation** | **Finland** |
|---|---|
| *Nine top-paying occupations:* | |
| Corporate managers | 0.049 |
| Physical, mathematical, engineering profess. | 0.002 |
| Life science and health professionals | 0.065 |
| Teaching professionals | 0.008 |
| Engineering science associate professionals | 0.039 |
| Other professionals | 0.146 |
| Life science and health associate professionals | -0.003 |
| Executive officers | 0.056 |
| Teaching associate professionals | 0.164 |
| | **0.058** |
| *Nine middle-pay occupations*: | |
| Metal. machinery and related trades work | 0.005 |
| Stationary-plant and related operators | -0.238 |
| Extraction and building trades workers | 0.022 |
| Models, salespersons and demonstrators | 0.060 |
| Precision, handicraft, printing, etc. | 0.095 |
| Drivers and mobile-plant operators | 0.011 |
| Machine operators and assemblers | 0.075 |
| Customer services clerks | 0.001 |
| Office clerks | 0.010 |
| | **0.005** |
| *Four lowest paying occupations:* | |
| Other craft and related trades workers | 0.043 |
| Labourers in construction and manufacturing | -0.012 |
| Personal and protective services | -0.012 |
| Service elementary occupations | 0.024 |
| | **0.011** |